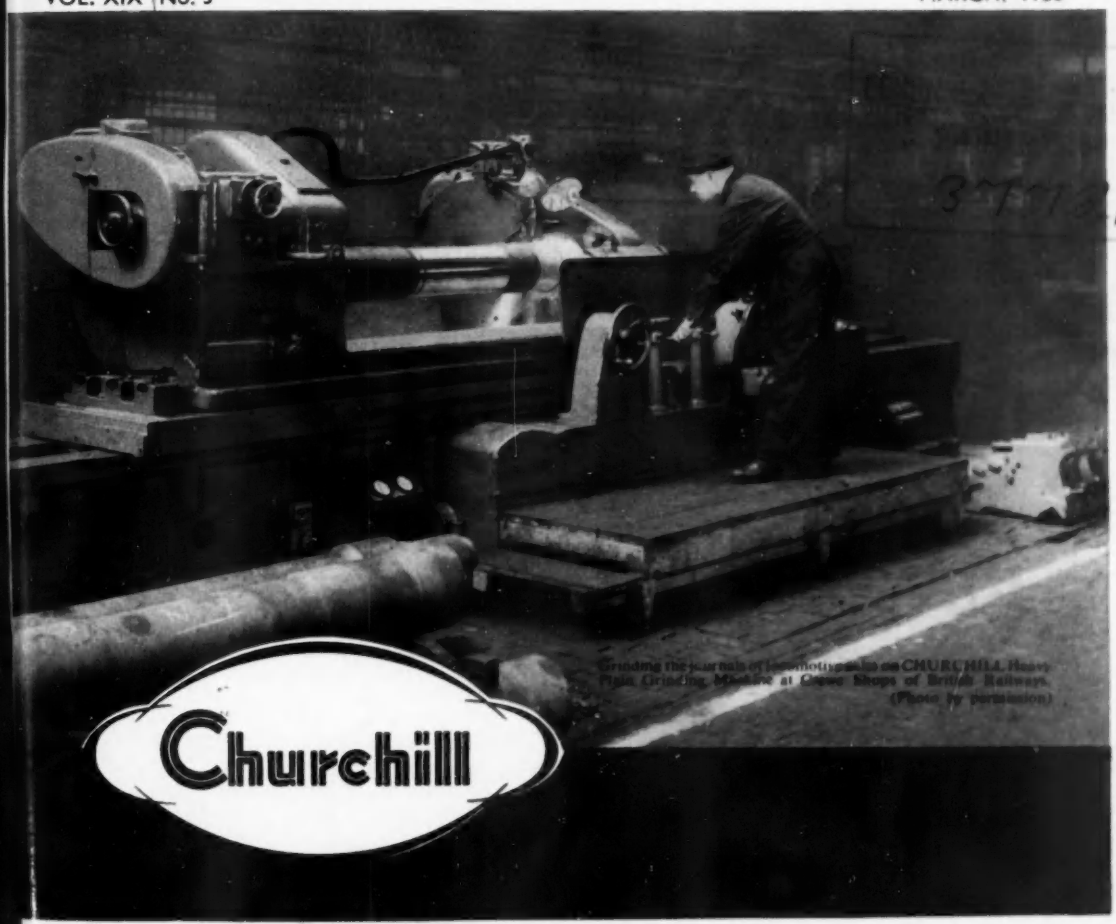
The
ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS
VOL. XIX No. 3 MARCH, 1958



THE CHURCHILL MACHINE TOOL CO. LTD., BROADHEATH, MANCHESTER

Export Sales Organisation: Associated British Machine Tool Makers Ltd., London, Branches and Agents.
Home Selling Agents: Charles Churchill & Co. Ltd., Birmingham and Branches.

PRECISION *plus* PRODUCTION

for over 100 years . . .

Engineers, Architects and Designers have been coming to Hall Harding. With over a hundred years of experience behind us, we pride ourselves that we can anticipate and supply their every need— from a single photo copy to a complete print room, from a set-square to a complete drawing office.

HALL HARDING LIMITED

STOURTON HOUSE, DACRE ST. LONDON S.W.1

BRANCHES: BATH · BELFAST · BIRMINGHAM · BRIGHTON · CARDIFF · DERBY · GLASGOW · HUDDERSFIELD · LEEDS · LONDON (4) · MANCHESTER MIDDLESBROUGH, YORKS · NEWCASTLE-UPON-TYNE · NEWPORT, MON. · PORTSMOUTH · SOUTHAMPTON · STOKE-ON-TRENT · WOLVERHAMPTON

---

now

WRITE FOR A NEW BOOKLET

"Cronite"

REGD. TRADE MARK

The **HIGH TEMPERATURE ALLOY**

SALT, LEAD AND CYANIDE VESSELS
CARBURIZING BOXES AND POTS
ROTARY RETORTS & PROPELLING WORMS
FURNACE HEARTHS AND FITTINGS
ENAMELLING PERRITS AND SUPPORTS
GLASS-BLOWING NOZZLES
PYROMETER PROTECTION SHEATHS
CASTINGS FOR USE AT 700 1200 C.

The **CRONITE FOUNDRY Co. LTD**

LAWRENCE RD · TOTTENHAM · LONDON N15

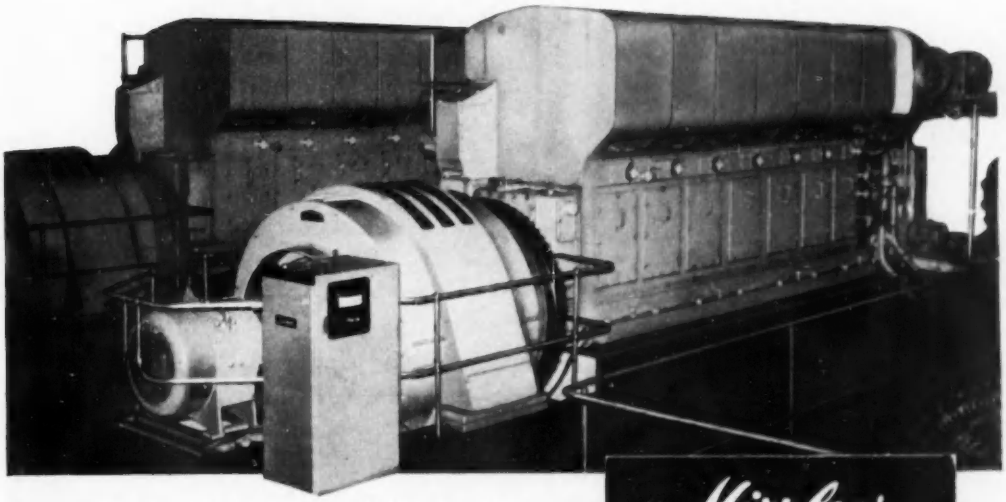
PHONE · STAMFORD HILL 4237

Mirrlees

diesel power for AUSTRALIA

Very different from the tough, arid territory of fifty years ago, when sun-baked cattle drovers defied the desert plains and tropical climate of the Northern Territory, the township Darwin is a new, pleasant, open post-war town with a population of 8,500 — the 'front-door' of Australia for aircraft to and from the north.

The power station supplying Darwin with electric power was built by the Department of Works; in it are installed three Mirrlees H F.S.8 engines, each developing 1266 B.H.P./850 kW at 375 rpm and two Mirrlees KS7 engines, each developing 1391 B.H.P./970 kW at 428 rpm.

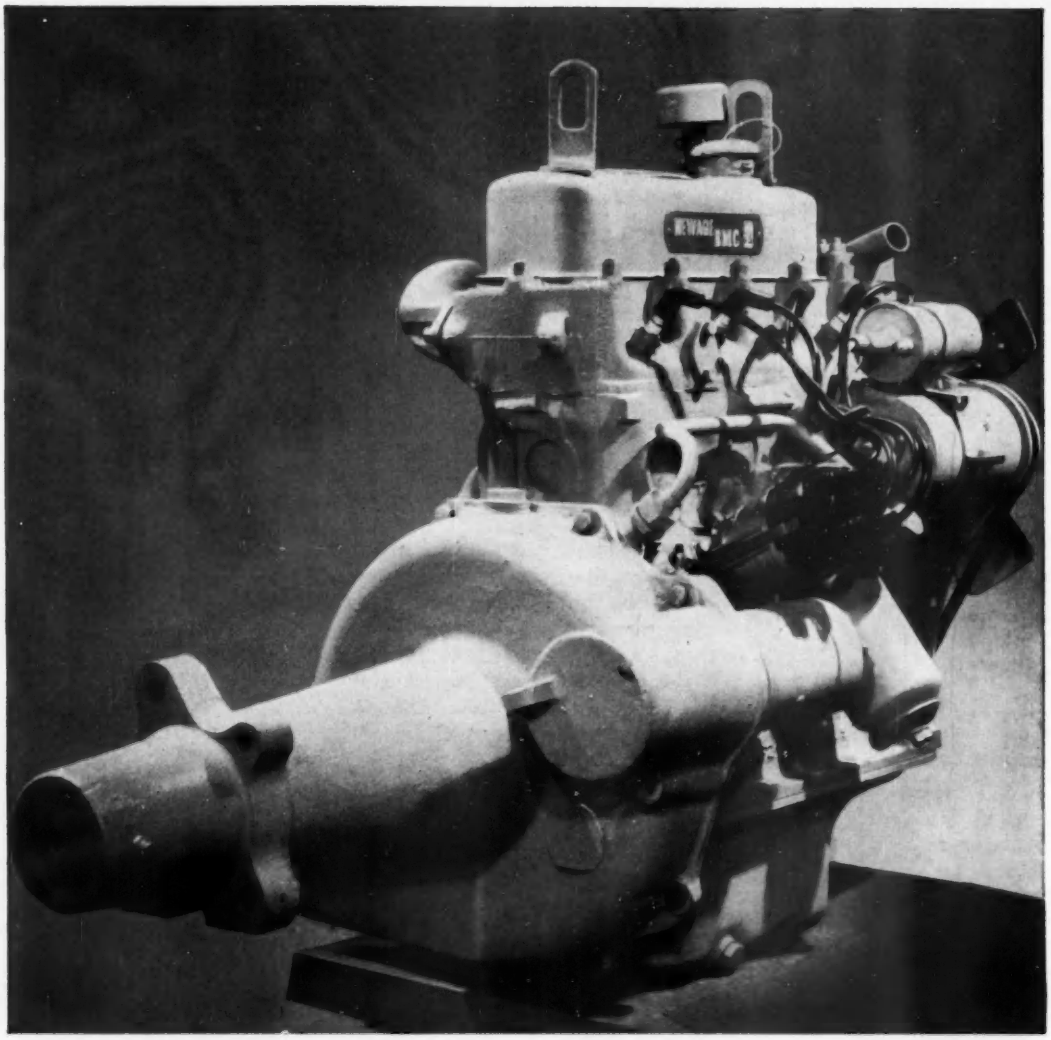


★ STOP PRESS—A further Mirrlees KSS8 engine has just been ordered for this station.

MIRRLEES, BICKERTON AND DAY LIMITED
A Member of the HAWKER SIDDELEY Group.
HAZEL GROVE · STOCKPORT · CHESHIRE
Telephone: Stepping Hill 3841 (14 lines)
Telegrams: "Mirrlees Telex, Manchester"

Mirrlees
diesels

IE 7



NEWAGE GROUP

The symbol of the Newage Group is the hall-mark of first-class engineering

Newage-BMC offers a choice of petrol/paraffin (gasoline/kerosene) engines from 950 to 4,000 c.c., and diesels of 2.2, 2.55, 3.4, and 5.1 litres.

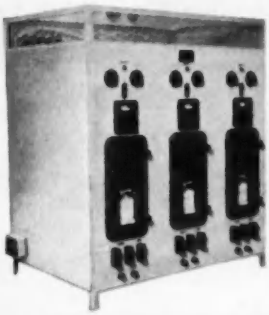
NEWAGE (MANCHESTER) LTD.

Home Sales and Works: Crossley Street, Gorton, Manchester, 18
Telephone: East 2071

Export Sales: 6 Carlos Place, Grosvenor Square, London, W.1
Telephone: Hyde Park 9141

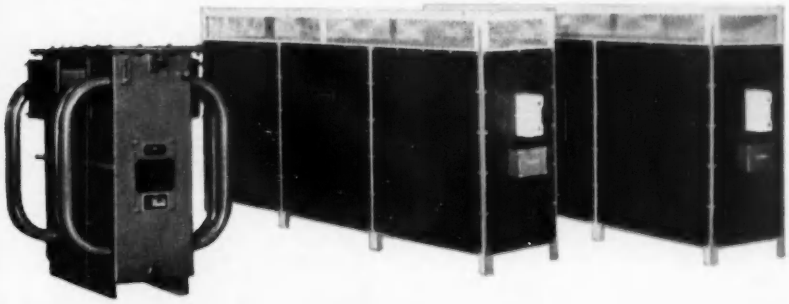
FORMULA FOR EFFICIENCY

To provide the perfect power unit for the Massey-Ferguson 735 Combine Harvester, Newage evolved this characteristically successful conversion of the BMC 1500 c.c. petrol engine. What they did for Massey-Harris-Ferguson, they can do for you. By applying the formula NEWAGE-BMC in the early stages of product development you can have any one of the magnificent range of BMC automotive engines — modified by the specialised skill of Newage engineers to conform to your own functional and installation requirements.



in rectifier equipment

you need G.E.C. reliability



G.E.C.

G.E.C. manufactures rectifier equipment to suit the needs of every industry.

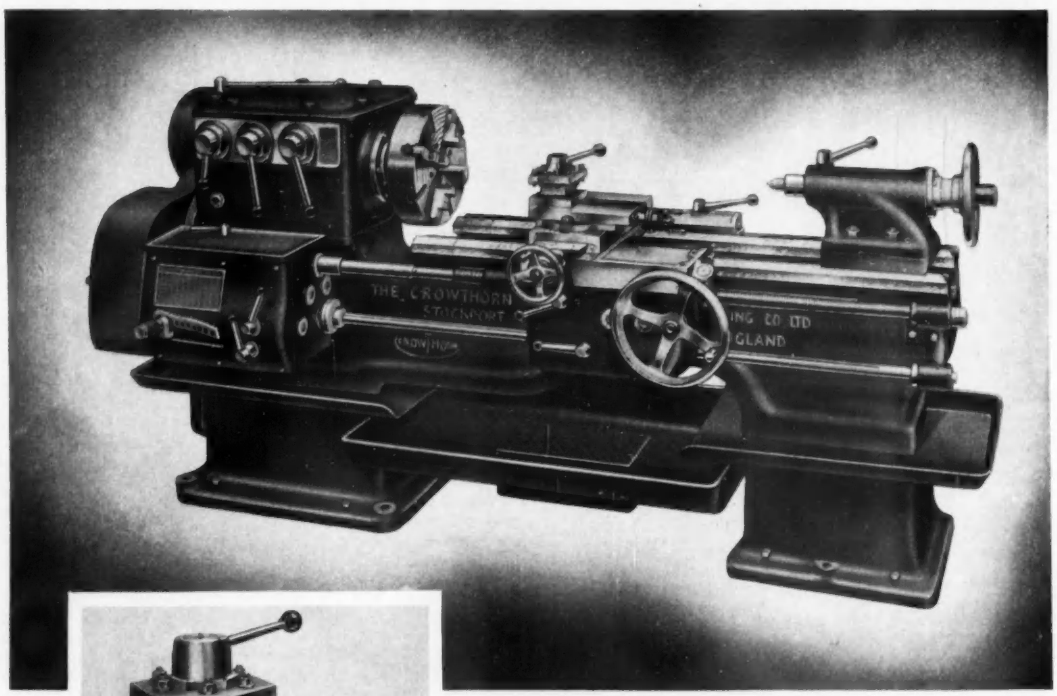
RECTIFIER EQUIPMENT

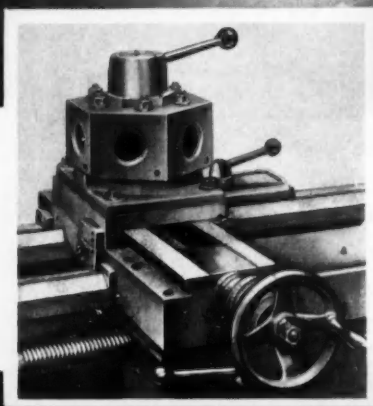
SELENIUM AND GERMANIUM

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

CROWTHORN

7½" & 8½" CENTRE LATHES





The most popular of the Crowthorn range, these lathes include in their specification a robust vee type bed, tinkenised headstock with large hollow spindle, quick change gearbox and multi position four way toolpost

A hexagon turret is available for either Herbert or Ward tooling equipment.

Please write for detailed literature.

CROWTHORN ENGINEERING COMPANY LIMITED

High Class Machine Tool Makers

REDDISH · STOCKPORT · ENGLAND

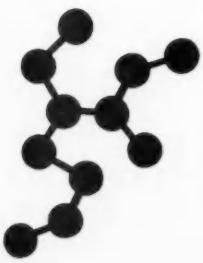
Phone: STOCKPORT 7271-2-3 *Grams: CROWTOOL, REDDISH*

A trustworthy service—

The efficient machining of metals presents problems of such importance that we, as specialist oil manufacturers, undertake considerable research work in order to arrive at facts that will permit the selection of Cutting Oils on a scientific and thoroughly reliable basis. It frequently happens in the machine-shop that this selection is not based on any sound consideration at all, different plants performing the same operation on the same machine and metal, often showing wide variation in type of Cutting Oil used and results obtained.

Cutting Oils to meet present-day requirements can be made available, some standard, some very special, and satisfactory machining cannot be accomplished without them. With the increasing use of special steels and advanced machining methods the old " hit and miss " methods will not do.

Our organization is tireless in basic research to ascertain the usefulness of various constituents in Cutting Oils and to determine their influence on current machining problems. We have been engaged in metal cutting oil development for nearly sixty years and are recognized as the foremost authority.



Edgar Vaughan & Co Ltd

BIRMINGHAM · 4 · ENGLAND

Works and depots at:
Birmingham, Manchester, Liverpool, Southall (Middx.), Bristol, Glasgow

NEWALL

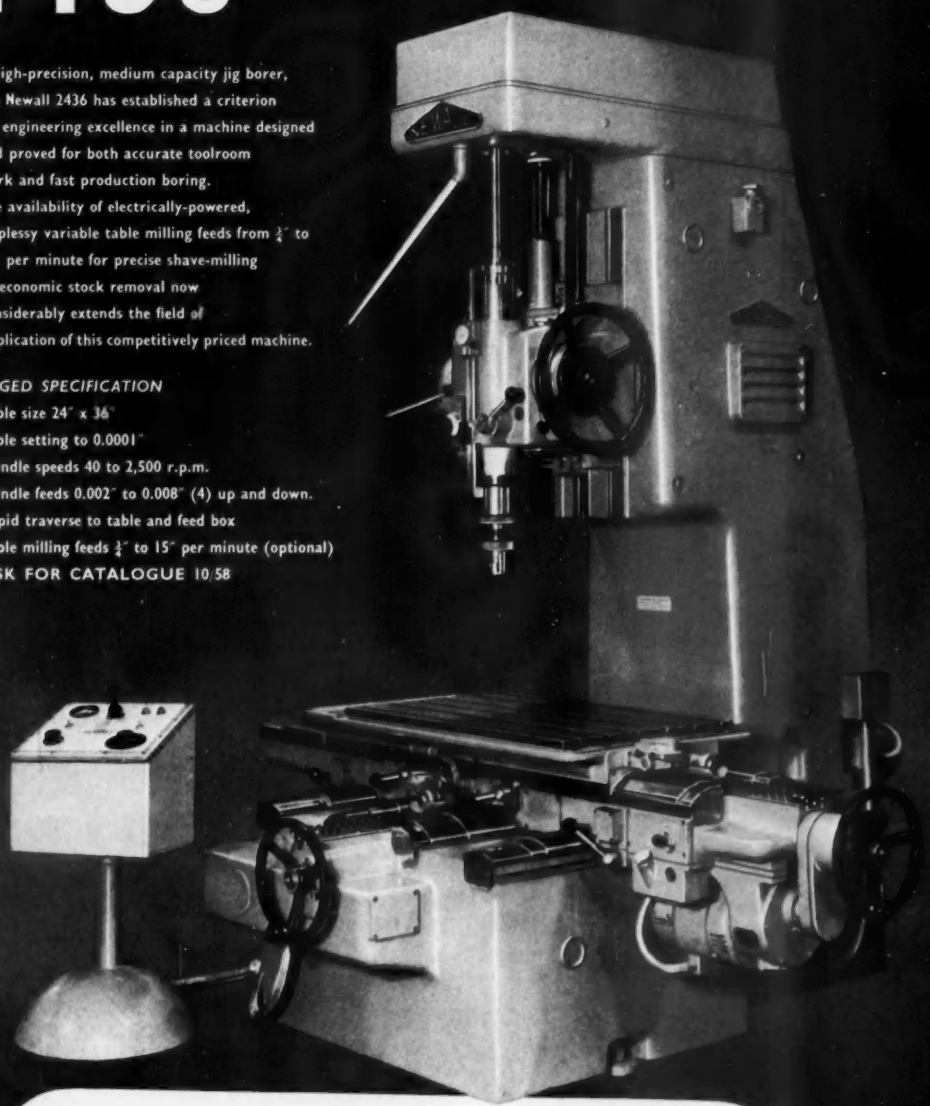
2436 JIG BORING AND MILLING MACHINE

A high-precision, medium capacity jig borer, the Newall 2436 has established a criterion for engineering excellence in a machine designed and proved for both accurate toolroom work and fast production boring. The availability of electrically-powered, steplessy variable table milling feeds from ¼″ to 15″ per minute for precise shave-milling or economic stock removal now considerably extends the field of application of this competitively priced machine.

ABRIDGED SPECIFICATION

Table size 24″ x 36″
Table setting to 0.0001″
Spindle speeds 40 to 2,500 r.p.m.
Spindle feeds 0.002″ to 0.008″ (4) up and down.
Rapid traverse to table and feed box
Table milling feeds ¼″ to 15″ per minute (optional)

ASK FOR CATALOGUE 10/58



NEWALL GROUP SALES LIMITED

PETERBOROUGH ENGLAND

Telephone: PETERBOROUGH 3227 *Telegrams:* 'PRECISION' PETERBOROUGH

HOW MANY HOLES?

'DOUBLE MUSHET'
HIGH-SPEED STEEL
TWIST DRILLS

We do not know the number of holes made every day throughout the world by fast-cutting "Double Mushet" drills, but we do know that all of these drills are of consistent top quality. Manufacture throughout within the same organization makes possible rigid production control and inspection, from the melting of the steel to the despatch of the finished product.

POCKET DRILL SETS

Four sets of drills are available packed in attractive metal containers of cigarette case size. No more lost drills for the Practical Engineer and Handyman.
Please write for descriptive folder.

OSBORN

FINE STEELMAKERS · STEELFOUNDERS · ENGINEERS' TOOLMAKERS

SAMUEL OSBORN & CO. LIMITED

CLYDE STEEL WORKS, SHEFFIELD

Good work deserves a good wash . . .

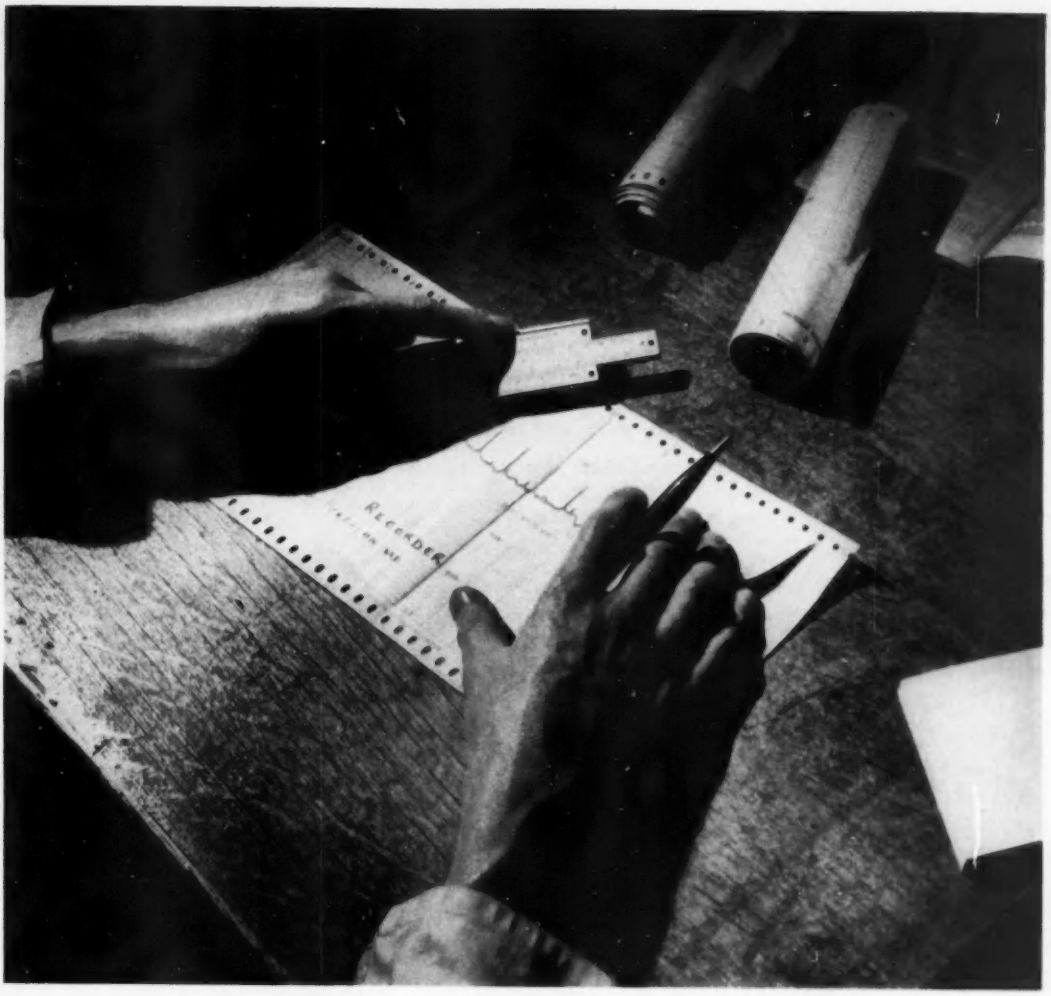
Save water, fuel and equipment and yet give the men plenty of warm water for a good wash at the end of the day's work. How? By fitting Leonard *thermostatic* valves which *automatically* mix hot and cold water to give warm water at the right temperature.

They are easily fitted in factory washrooms on wash troughs, wash fountains and showers, and make an up-to-date installation which saves water and cuts your fuel bill down.

More about this, with lists of users, in leaflet No. ZJ/24.

WALKER, CROSWELLER & CO. LTD., CHELTENHAM

Telephone: CHELTENHAM 54317



He counts on accuracy

He wants to know exactly what is happening; he wants an accurate record of what has been happening. So he studies the day's chart from his Arkon Recorder.

Arkon Recorders measure gas and air flow, pressure or vacuum, or pressure and vacuum; flows in one inch pipe or three foot mains, pressure or vacuum from 0.1 inches water gauge to 30 lb. per square inch. They give a clear, unmistakable record which you can read like a book, without hesitation and without mistakes. You can leave the chart on for a few hours, a day, or a week—the record will always be there. Easily read, easy to look after, robust enough to stand on the job, Arkon Instruments can help the control of any process—and their accuracy will satisfy even the men in the lab.

More about them in pamphlet AA/24

WALKER, CROSWELLER & CO. LTD., CHELTENHAM

Telephone: CHELTENHAM 56317

ahead with
lower machining times
Saving time . . . automatic sequence. The heads are slide-mounted horizontally, vertically, or at angles, on a wide range of standard columns and bases, which, with rotary tables and other equipment, ensure that your requirements are normally met ex stock.

Sentinel machine tools incorporating the

Renault - France system electro-mechanical heads

Sentinel Unit Machines are built up from standard bases (with enclosed switchgear) and rotary tables, all of which have machined mating faces for assembly into varied combinations of units

Vertical Column 7-8-9 ft.
3 ft. Wet Base
3 ft. Dry Base
5 ft. Dry Base
5 ft. Wet Base
5 ft. Dry Base
Base for Vertical Column
4-Way Centre Base
Bridge Column on 4 ft. Dry Base

SENTINEL (SHREWSBURY) LTD SHREWSBURY ENGLAND

Telephone: SHREWSBURY 2011 Telegrams: "SENTNOLL SHREWSBURY" London Office: 60 BUCKINGHAM PALACE ROAD LONDON S.W.1

P4565

The Trans-Antarctic Expedition is essentially a scientific project. And the scientific approach leaves no room for chance or guesswork—in preparation or execution. For example, the sledge runners have been faced with TUFNOL to combat the extremely arduous conditions of travel. TUFNOL was also used for gear wheels in the SMITHS sledge meters which record the distance of travel with the maximum possible accuracy.

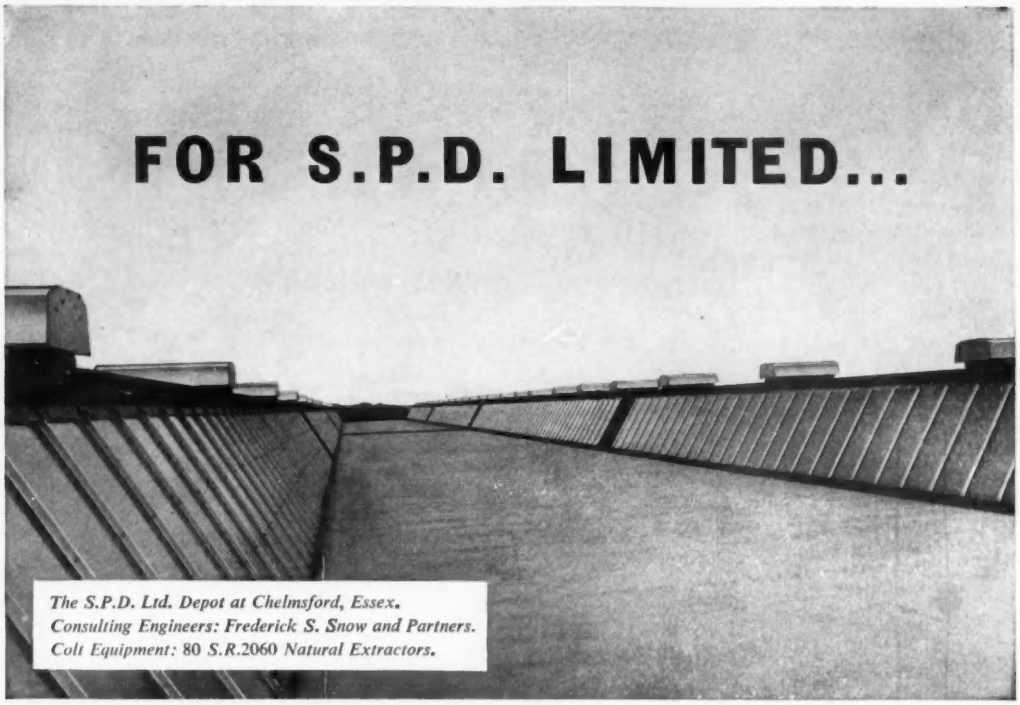
This confidence in TUFNOL has been endorsed by pioneers in other fields. In electronics and in nuclear research, in shipbuilding and in aircraft construction, in steelmaking and in almost every other branch of engineering, the advantages of TUFNOL have won lasting recognition.

TUFNOL
REGISTERED TRADE MARK
An ELLISON Product

TUFNOL LTD • PERRY BARR • BIRMINGHAM • 22B

324

FOR S.P.D. LIMITED...



The S.P.D. Ltd. Depot at Chelmsford, Essex.
Consulting Engineers: Frederick S. Snow and Partners.
Colt Equipment: 80 *S.R.*2060 *Natural Extractors.*

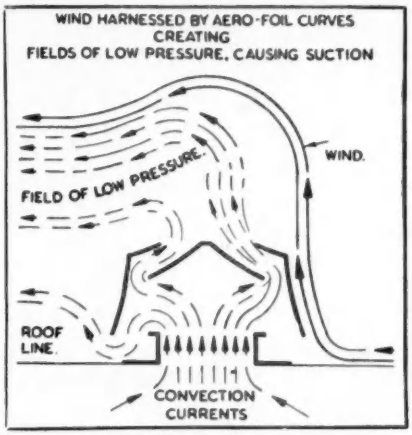
In S.P.D. depots throughout Great Britain, the complex ventilation requirements of these warehouses are being met by Colt Natural Ventilation systems.

The installation of Colt S.R.2060 Ventilators, shown above at the Chelmsford depot, is the Colt solution to an intricate problem concerning the relationship between ventilation and structural insulation ; both of them essential to the products stored.

Every problem Colt tackle receives the same meticulous attention. Colt have practical experience in installing ventilation systems for over 10,500 firms throughout the world.

A Technical and Advisory Staff are ready to adapt this knowledge to your particular requirements.

Let COLT solve YOUR problem.



Send for Free Manual on Colt Ventilation to Dept. U 15/3

COLT **VENTILATION**

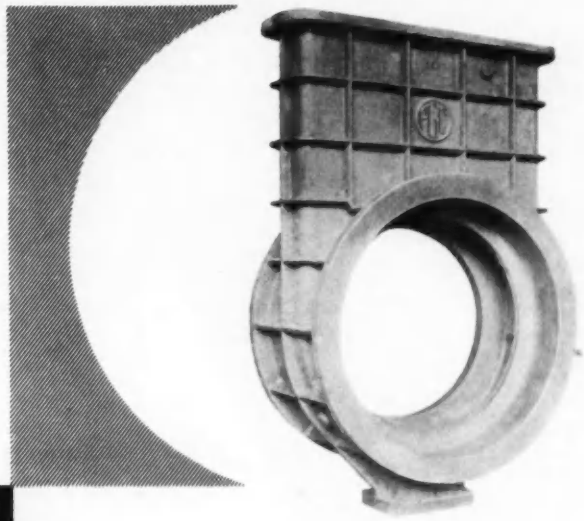
COLT VENTILATION LTD · SURBITON · SURREY
TELEPHONE: ELMBRIDGE 6511 (10 lines)

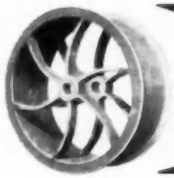
U.S.A. Subsidiary : Colt Ventilation of America, Inc., Los Angeles.
Branches at : Birmingham, Bradford, Bridgend (Glam.), Bristol, Dublin, Glasgow, Leamington Spa, Liverpool, London, Manchester, Newcastle-upon-Tyne, and Sheffield. • Agents in : Australia, Belgian Congo, Belgium, Burma, Canada, Cyprus, India, Indonesia, Madagascar, Malaya, Mauritius, New Zealand, Pakistan, Portugal, Rhodesia and Nyasaland, South Africa, and West Indies.

G 6868

See our exhibit at the Factory Equipment Exhibition, Earls Court—Stand No. C24

FOR IRON CASTINGS SPECIFY
ASHMORE'S MEEHANITE





Ashmore's MEEHANITE castings are produced under strict metallurgical control ensuring consistent properties for the service required.

MEEHANITE is produced in many grades to meet specific requirements, whether for heat, wear or abrasion resisting applications.

Ashmore, Benson, Pease & Co. will be pleased to advise the grade suitable for your application. Upon request, a specification booklet will be posted to you.

Capacity is available for producing castings up to 20 tons weight or 13 feet diameter, by modern methods and processes.

QUALITY ASHMORE'S MEEHANITE AND SERVICE

The 42" gas valve illustrated above weighs 3 tons 3 cwt. and is made in heat resisting MEEHANITE to withstand a working temperature of 700° C. The lower photograph is of a colliery rope drum weighing 1 cwt. 3 qrs.

ABP

ASHMORE, BENSON, PEASE & CO

(MEMBER OF THE POWER-GAS GROUP)

STOCKTON-ON-TEES AND LONDON

AUSTRALIA • CANADA • INDIA • FRANCE • SOUTH AFRICA

383

DELORO STELLITE ALLOYS

Stellite X40 Alloy vanes in Napier 'Eland' nozzle guide assembly

The resistance to destruction of Deloro Stellite Alloys is worth investigating. Heat, abrasion and corrosion resistance is of a high order. Even combinations of these destructive effects make little impression on these remarkable alloys.

● ***Send for publication SP13 which gives properties of some of the alloys in the wide range.***

The Napier 'Eland' propeller turbine aero engine

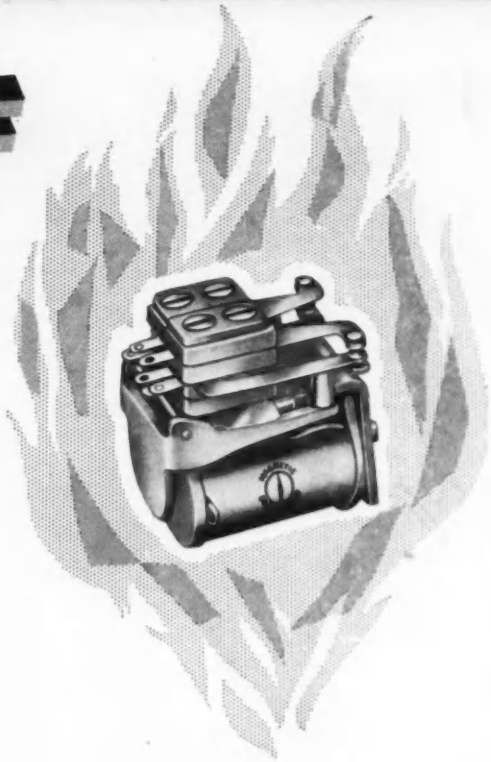
FOR HEAT RESISTANCE

ALSO PROOF AGAINST CORROSION AND ABRASION

DELORO STELLITE LIMITED · HIGHLANDS ROAD · SHIRLEY · SOLIHULL · WARWICKSHIRE · ENGLAND
DIV. OF DELORO SMELTING & REFINING CO. LTD. · BELLEVILLE · ONTARIO · CANADA

AD.NO.245

302° F



The 596 High Temperature Relay

The 596 High Temperature Relay is capable of continuous operation in ambient temperatures of up to 302° F. or 150° C. The coil voltage is up to 75 volts D.C. and the contact rating is 3 amps. at 250 volts A.C. The contact current rating may be increased when operating in ambient temperatures below maximum.

Magnetic Devices LTD.

A.I.D. and A.R.B. APPROVED

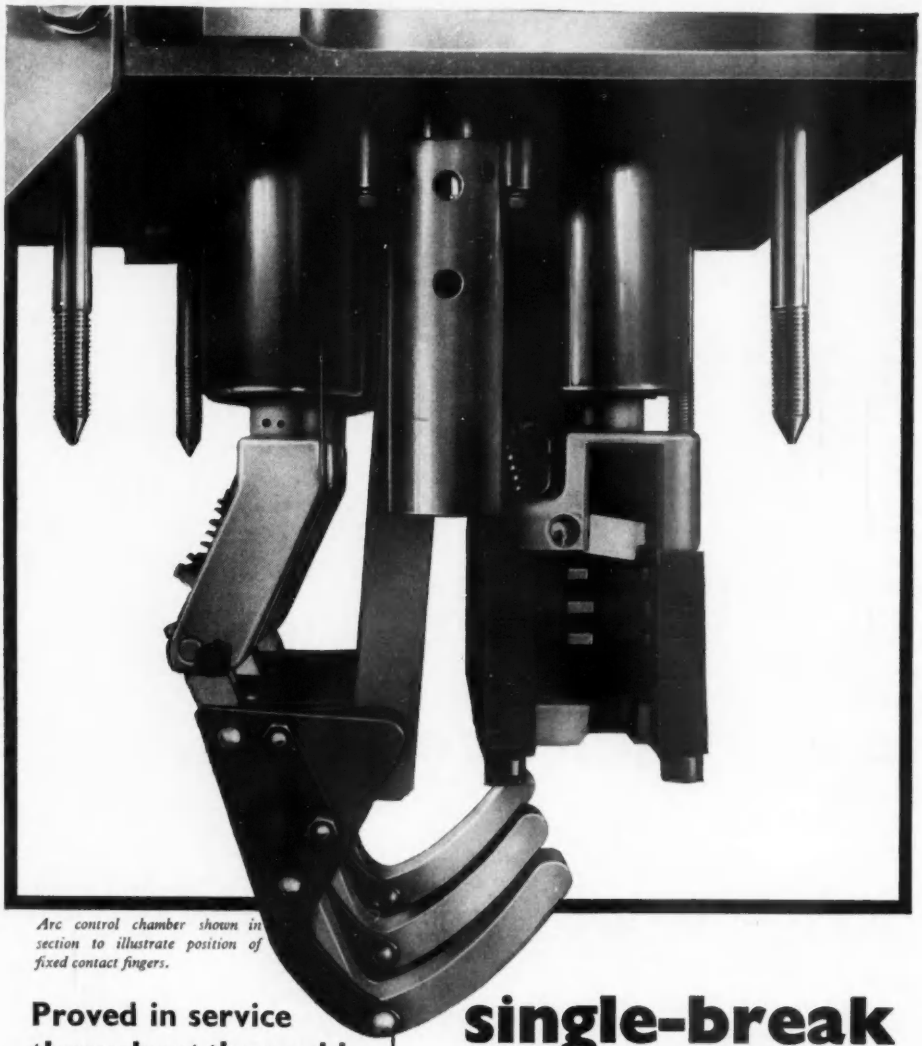
EXNING ROAD, NEWMARKET, SUFFOLK

Telephone: Newmarket 3181 2 3 Telegrams: Magnetic Newmarket

MAGNETIC DEVICES LIMITED

MD 16A

A15



Arc control chamber shown in section to illustrate position of fixed contact fingers.

Proved in service throughout the world

BTH single-break oil circuit-breakers—designed for metalclad switchgear—have the inherent advantages of compactness, simplicity, and ease of maintenance. The arc-control chambers and silver-plated high-pressure line contacts ensure high performance and consistent operation.

single-break oil circuit-breakers

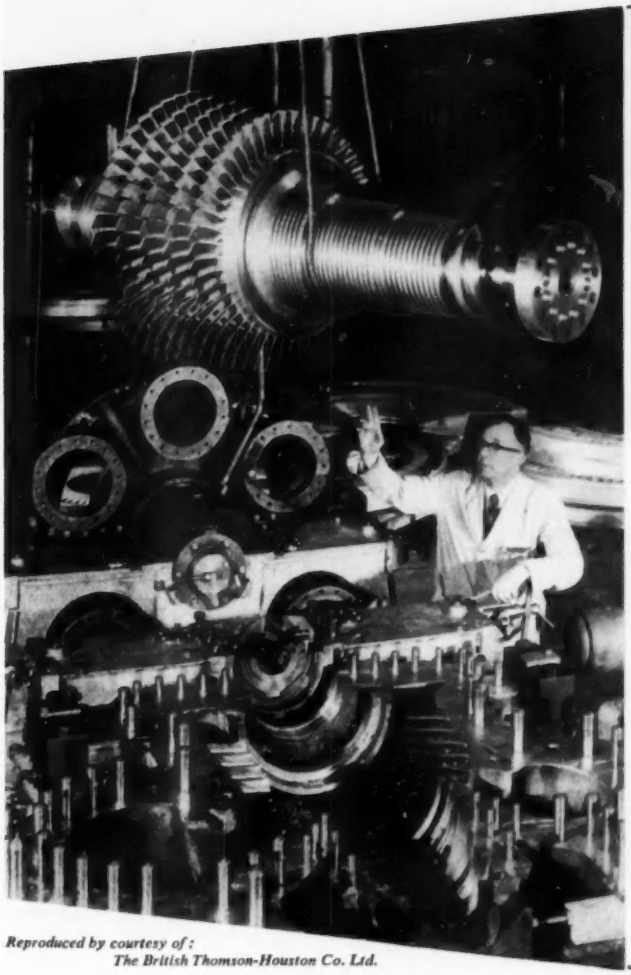
by B T-H

up to 15 kv. **up to 2,000 amp.**

THE BRITISH THOMSON-HOUSTON COMPANY LIMITED · WILLESDEN · ENGLAND

an A.E.I. Company A5130

A.S.E.E. EXHIBITION—VISIT OUR STAND No. J.12



Reproduced by courtesy of:
The British Thomson-Houston Co. Ltd.

High pressure turbine rotor for the new 5,500 b.h.p. gas turbine for the Shell Tanker "Auris", the first ocean-going merchant vessel in the world to be fitted with a gas turbine. All the stainless steel and "Nimonic" blades for this rotor were drop forged by Firth-Derihon.

A 16mm Colour Film with sound commentary, entitled "Drop Forgings in Alloy Steels," is available on request.

Disc and Blade Drop Forgings for the Turbine Industry

by

FIRTH-DERIHON

SHEFFIELD & DARLEY DALE

THE FIRTH-DERIHON STAMPINGS LIMITED

The illustration shows a Water Meter Piston, a Valve Anode, a Pump Vane, a Sealing Ring, a Rectifier Grid and a Welding Rod — just a small selection of products showing the remarkable versatility of Morganite Carbon.

. . . *that's the beauty of it*

Look at these advantages — Light as aluminium. High resistance to wear. Wide range of resistance to chemical attack. Easily machined. High thermal conductivity. Excellent heat radiation. Not wetted by molten metal or slags. Non-seizing. Self-lubricating. High resistance to thermal shock. Good mechanical strength at high temperatures. Good electrical conductivity. Available in impervious forms. Low thermal expansion. These properties give Morganite Carbon vast potentialities for the design engineer. Talk them over with our technical staff.

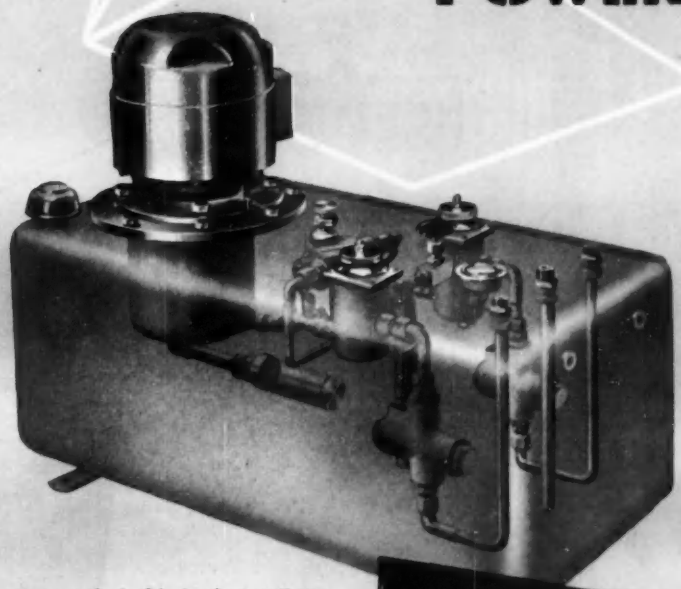
MORGANS

CARBON AND GRAPHITE — ELECTRICAL, CHEMICAL AND MECHANICAL; CRUCIBLES, FURNACES, REFRACTORIES; RADIO PARTS; SINTERED METAL PRODUCTS AND ELECTRIC FURNACE ELEMENTS.

THE MORGAN CRUCIBLE COMPANY LTD., BATTERSEA CHURCH ROAD, LONDON, S.W.11. BAT: 8822

C59/A

PRE-PACKED HYDRAULIC POWER



...the modern method of hydraulic installation

No more inefficient and unsightly long pipe runs when you use a Keelavite power pack. Just couple the pack to the actuators and the complete system is ready for operation.
Packs are assembled from standard units of equipment to meet specific power and control requirements.

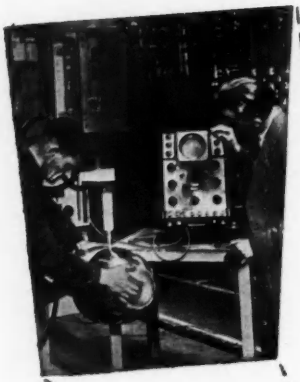
Keelavite

POWER PACKS

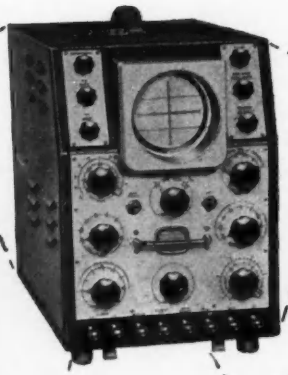
THE RECOGNISED AUTHORITY ON HYDRAULIC POWER TRANSMISSION

KEELAVITE ROTARY PUMPS & MOTORS LTD., ALLESLEY · COVENTRY · ENGLAND
Tel.: MERIDEN 441 'Grams: KEELAVITE · COVENTRY

The Engineering Centre Group Stand—BLOCK C—British Industries Pavilion at the Brussels Universal & International Exhibition—April/October



INVALUABLE IN EVERY FIELD OF INDUSTRY



COSSOR OSCILLOGRAPHS

Trial-and-error methods of fault evaluation are outmoded, inaccurate and expensive. With a Cossor Oscillograph, the modern Engineer is armed with an instrument that will display, measure and time the action of his electrical or mechanical machinery with precision, speed and certainty. It is worthwhile, therefore, to investigate the possibilities of these versatile instruments in *your* Industry by writing to:

COSSOR INSTRUMENTS LIMITED

The Instrument Company of the Cossor Group

COSSOR HOUSE · HIGHBURY GROVE · LONDON, N.5

Telephone: CANonbury 1234 (33 lines) Telegrams: Cossor, Norphone, London Cables: Cossor, London

CI 104

TYPE V B III Z

Upright, multiple and adjustable spindle Drilling machine, fitted with hydraulically controlled head and automatic work cycle

MAIN CHARACTERISTICS :

Number of right hand rotation spindles which can be fitted	16 or 24
Drilling capacity for each single spindle	32 or 23 mm.
Maximum field of drilling	650 x 410 mm. or 500 mm. dia.
Rotaty spindle speeds with single gear change	12
Continuously variable feed speeds	20-450 mm/min.
Installed power	16 hp.
Feed thrust	4500 Kg.
Weight of machine	5000 Kg.

Various types of spindles whether on adjustable or orientable fittings, can be used according to the needs of the moment. SIX Types OF WORK TABLE

Upright Sensitive & Automatic Drills
Multi-spindle Hydraulic Cycle
Machines, for combined operation
Drilling, Boring, Tapping and Drilling
Horizontal Units (Hydraulic automatic cycle)
Multi-spindle tapping machines
Hydraulic plain-milling machines
Rotary transfer tables

BERARDI

OFFICINE **RINO BERARDI** - BRESCIA - ITALIA
VIA ALESSANDRO LAMARMORA, 105 - TELEFONO 38-009
Associata all' U.C.I.M.U.
UFFICIO ESPORTAZIONE: 26, Via Borgonuovo - MILANO - ITALIA

TAYLOR-HOBSON

PRESENT THE

NEW

JH

ENGRAVING MACHINES

Ask for Lists 800-16 and 2-2H

A Member of RANK PRECISION INDUSTRIES LTD.

TAYLOR, TAYLOR & HOBSON LTD., LEICESTER

DORMER SILVER RING
is a registered Trade Mark

SILVER RING

— recognised for supreme performance

DORMER

TAPER SHANK
TWIST DRILLS

OUTSTANDING
AMONG
ALL OTHERS

THE SHEFFIELD TWIST DRILL AND STEEL COMPANY LIMITED
SHEFFIELD ENGLAND
DORMER TOOLS ARE OBTAINABLE FROM YOUR USUAL ENGINEERS' MERCHANTS

IMMEDIATE DELIVERY!

MORRIS

FOREMOST FOR SAFETY
— SINCE 1884

BALL - BEARING
ELECTRIC CHAIN HOISTS

Perfected in every detail.
Incomparable for safety, reliability,
efficiency and durability
They stand supreme.

In support of these claims we shall be pleased to send one to you ON APPROVAL. (Please state your current supply and the height of lift, hook to hook, required.)

WRITE FOR SECTION 80/28.

To lift tons	¼	½	1
PRICE £	70	70	79
* SPEED ft./min.	37	18½	9¼

* Higher speeds available

Resident engineers available for consultation in London, Glasgow, Manchester, Birmingham, Leeds, Sheffield, Newcastle, Cardiff, Bristol, Dundee, Liverpool, Nottingham and Bury St. Edmunds.

HERBERT MORRIS LTD P.O. Box 7 LOUGHBOROUGH ENGLAND

Telephone: Loughborough 3123

EXPERTS IN THE IMPOSSIBLE

Many of the run-of-the-mill jobs that our investment casting foundry turns out by the hundred or thousand started by being labelled 'impossible': complex shapes, bristling with re-entrant angles, in difficult machining metals like stainless, heat resisting, high speed and cobalt alloy steels.

Over the years we have developed our techniques and equipment to the point where we actually welcome the 'impossible'. Our foundrymen are experts, like these men in the photograph. They are relying on the reflex judgment of years of experience to decide when the melt will be ready to pour from the arc furnace.

In addition we can command the facilities of the Napier Metallurgical, Chemical and Mechanical Research Laboratories. This is how we are able to turn out many thousands of precision castings each week for all types of engineering projects, from aero and marine engines, aircraft, guided missiles, automatic machinery and farming machinery, right down to mechanical toys.

Perhaps *you* have a job which is costly to machine and (in your opinion) 'impossible' to cast. If so, we'd like to hear about it. We may be able to help you.

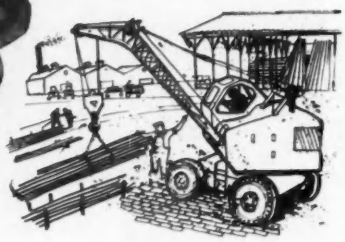
Our 24 page illustrated booklet, "Napier Investment Castings" is yours for the asking.

NAPIERCAST

FOR THE FINEST INVESTMENT CASTINGS

D. NAPIER & SON LIMITED · LONDON · W.3.

CBC NB



FORD *POWER* for industry

Ford industrial engines are a practical proposition for many industrial equipments . . . **compressors, cranes, pumps, contracting equipment, earth borers, generators, railcars, welding plant, works trucks, tractors and conversions.** Simple design, modern flow-line production methods and common interchangeable parts contribute to the low cost of these high efficiency engines. And remember, *every* Ford engine is fully backed by a World-wide Spare Parts Service Organisation. Take your choice from a wide power range . . . Diesel 30 to 86 b.h.p. and Petrol 21 to 87 b.h.p. (12-hr. rating).

DIESEL ECONOMY—have you considered the replacement of existing power units in your equipment and trucks with the famous Ford 4D Diesel engine? You'll have the unique advantages of economy, long-life and low running costs... plus the best service in the World!

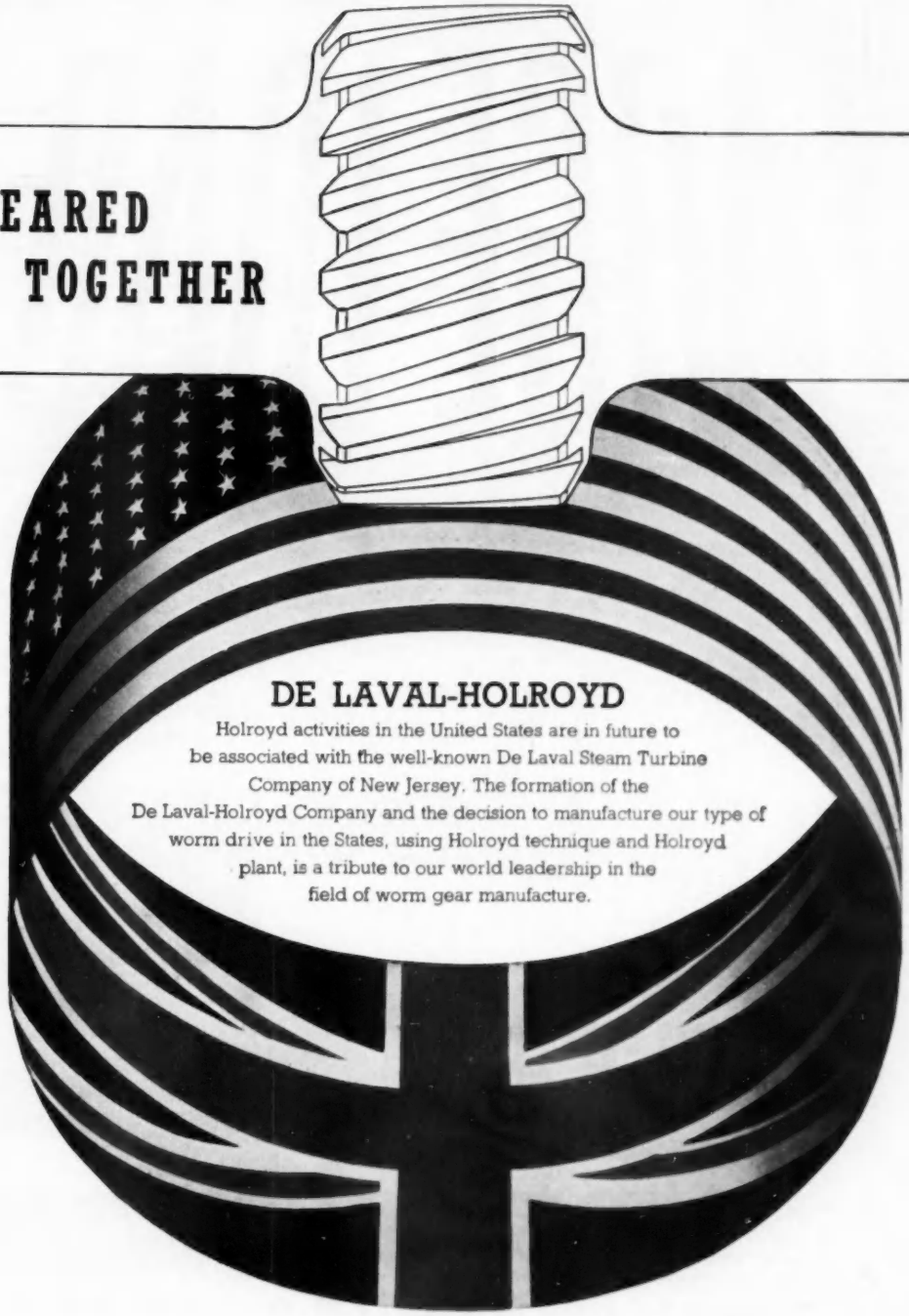
Wherever you are, whatever your problem, we are at your service. For further details of

FORD INDUSTRIAL ENGINES

and the equipments they power, contact your nearest Ford Dealer or write to

FORD MOTOR COMPANY LTD · PARTS DIVISION · AVELEY DEPOT · SOUTH OCKENDON · ROMFORD · ESSEX · ENGLAND

GEARED TOGETHER



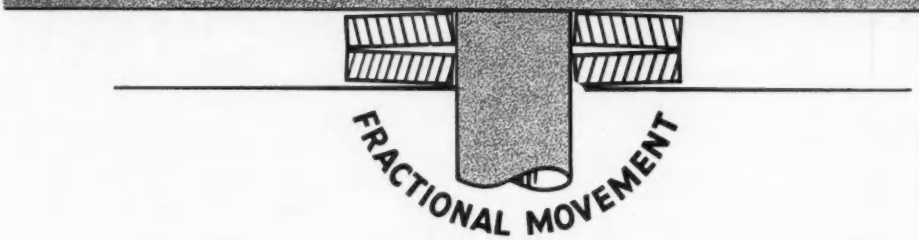
DE LAVAL-HOLROYD

Holroyd activities in the United States are in future to be associated with the well-known De Laval Steam Turbine Company of New Jersey. The formation of the De Laval-Holroyd Company and the decision to manufacture our type of worm drive in the States, using Holroyd technique and Holroyd plant, is a tribute to our world leadership in the field of worm gear manufacture.

JOHN HOLROYD & CO. LTD. · MILNROW · LANCASHIRE · ENGLAND

CBC/67

LARGE LOAD



. . . and the Belleville makes it possible . . . !

The largest capacity spring balance in the world. This instrument was made to weigh giant steel castings and is graduated up to 200 tons with 1 ton sub-divisions. It is approved by the Board of Trade for "Trade" purposes, where the requirement is that the machine must be accurate to within a quarter of its smallest sub-division.
Two Belleville washers, in this instance opposed to each other, supply the spring resistant. Their total movement under full load of 200 tons is never more than $\frac{1}{16}$ of an inch.

SALTER . . .

. . . always a spring ahead!

★ When resistance to load or thrust is beyond the capacity of helical springs,

★ When take-up of shock or sustained load must be restricted to very slight movement,

★ When many tons of dead load must be sustained plus intermittent shock or live load . .

. . . it's time to call in SALTER technicians!

GEO. SALTER & CO. LTD., WEST BROMWICH, ENGLAND . ESTABLISHED 1760

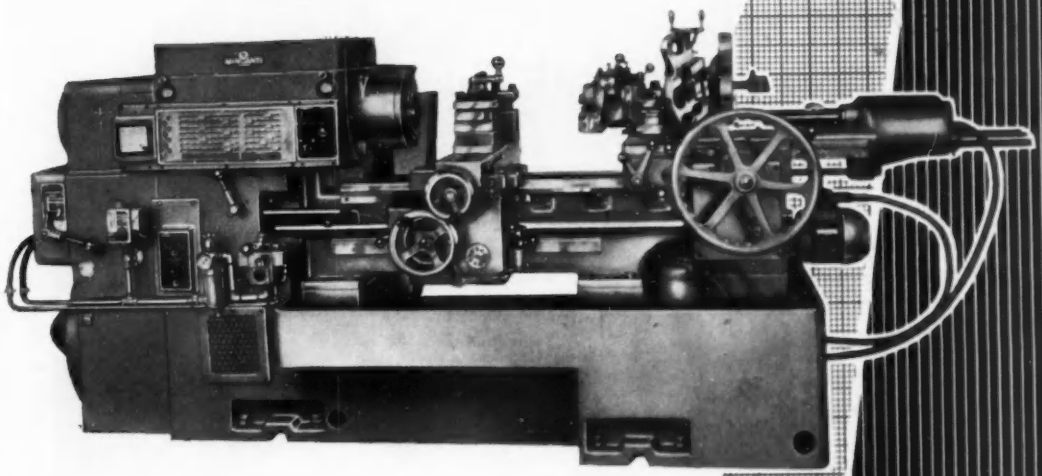
AUTOMATIC TURRET LATHE

50/E

The machine which "Thinks,, for the Operator

NO ERRORS
NO REJECTS
FATIGUE ELIMINATED

The advantages of Copying Lathes Coupled with those of Multiple Set-up



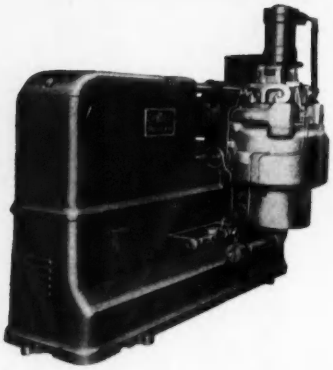
Standardized spindle end	ASA 6"
Dia. of hole in spindle	2 1/4"
8 Spindle speeds (standard range) r.p.m.	80-1500
8 Spindle speeds (special range) r.p.m.	50-3000
Max. distance from spindle flange to hex. turret	25 5/8"
Max power required	HP 4-8—8
Net weight with standard equipments	lb. 6500

MACHINE TOOL BUILDERS

MINGANTI
BOLOGNA

EXPORT OFFICE

MILANO (Italy) - Piazzale P.ssa Clotilde 8 - Phone 637-193



You thoroughly understand the function of your product.
We thoroughly understand die casting problems.
Combining the two skills at an early period is logical and valuable.

TELEPHONE CARLISLE 21418

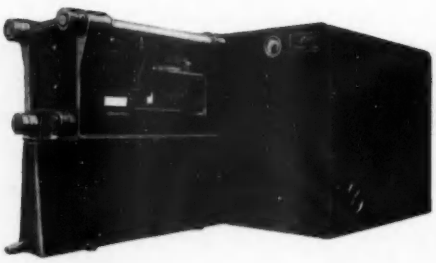
Coulthard Madison Kipp

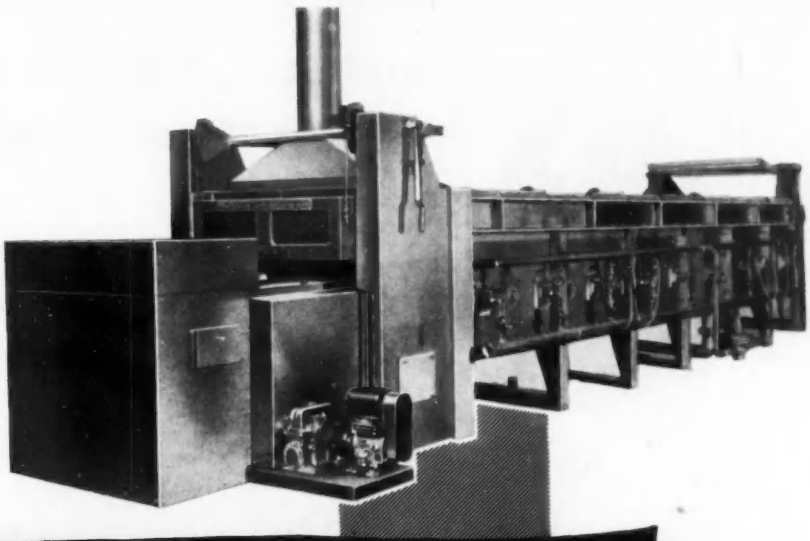
ENGINEERING DIVISION
DURRANHILL ROAD
CARLISLE

— signifying . . .
SKILL IN DIECASTING MECHANICS . . . and . . .

hi-high **PRESSURE DIE CASTING MACHINES**

Efficient





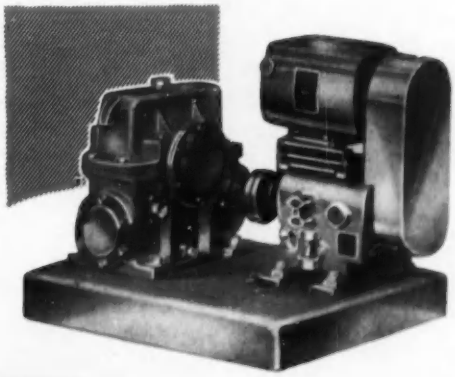
Another Carter Variable Speed Drive

This slow speed drive to a Gas Fired Continuous Tempering Furnace includes a Size F10 Carter Variable Speed Gear.

Built by the Dowson & Mason Gas Plant Co. Ltd., the process speed may be infinitely varied by means of the Carter Gear control, adjustable with the drive running or stationary.

Remote Electrical, Hydraulic, Hand or Lever controls are available with all sizes of Carter Gears.

Specialists for over 20 years in the design, manufacture and industrial application of Hydraulic Variable Speed Gears. For full details of the entire fractional up to 35 horse power range of Carter Variable Speed Drives write for Folder 658.

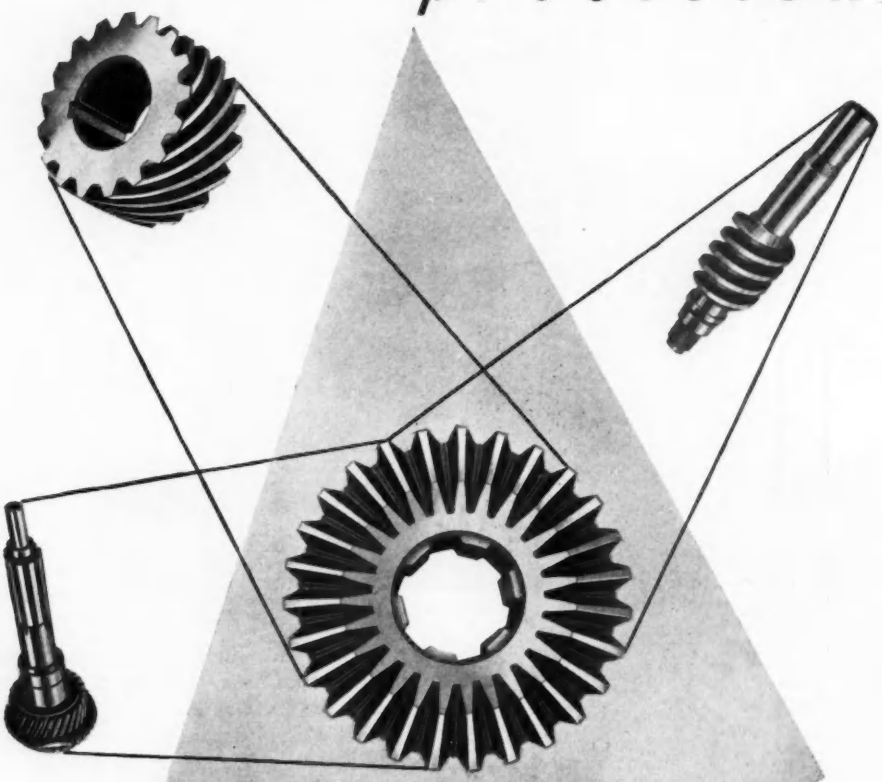


Carter Gears Limited

BRADFORD 3
YORKSHIRE
ENGLAND

'phone: Bradford 64378 (3 lines)
'grams: 'Became' Bradford Telex

precision



is the background

We have a standard range of Automotive and Industrial Gear Boxes, or can undertake the supply of loose gears and shafts to your own design.

P R

THE GEAR SPECIALISTS

Cut, ground or shaved Spur and Helical Gears. Ground Worms and Splines — Sprockets — Bevels — Reduction Units — Gear Boxes for all Trades.

A.I.D. Approved

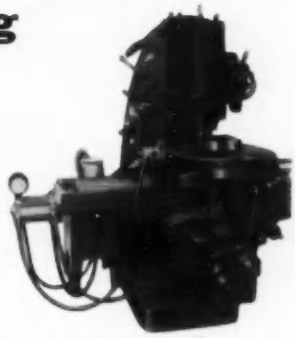
P. R. MOTORS LTD · ALDBOURNE ROAD · COVENTRY

Telephone : 2266 (3 lines)

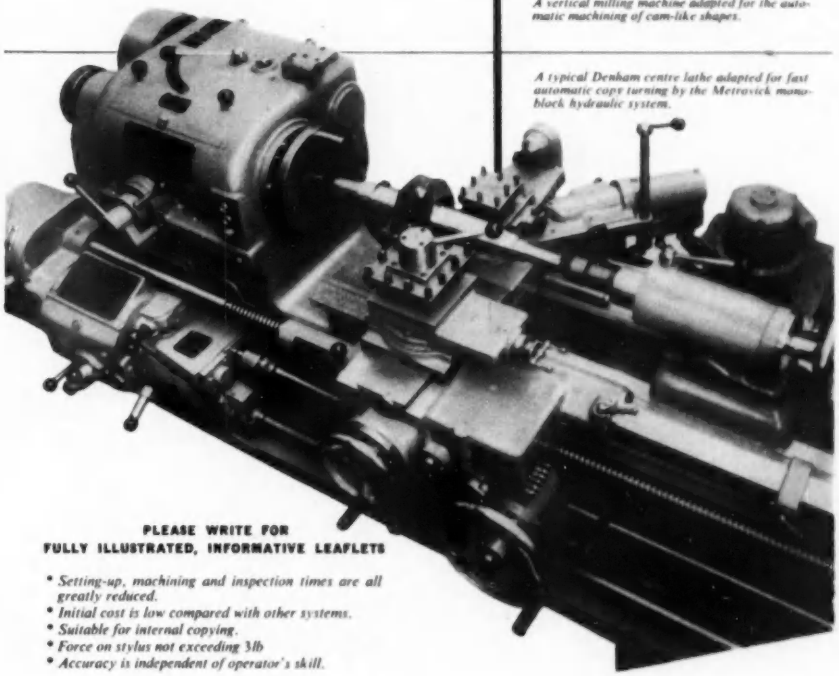
Telegrams : Supagears, Coventry

Convert your machine tools to automatic profiling

Centre lathes and machine tools of most types can be converted to fast automatic repetition work by means of the range of robust, reliable and economic hydraulic attachments made by Metrovick. Stepped shafts, tapers and intricate concave and convex shapes of every kind can all be turned with precision to match the contour of a master template or sample work-piece.



A vertical milling machine adapted for the automatic machining of cam-like shapes.



A typical Denham centre lathe adapted for fast automatic copy turning by the Metrovick mono-block hydraulic system.

PLEASE WRITE FOR FULLY ILLUSTRATED, INFORMATIVE LEAFLETS

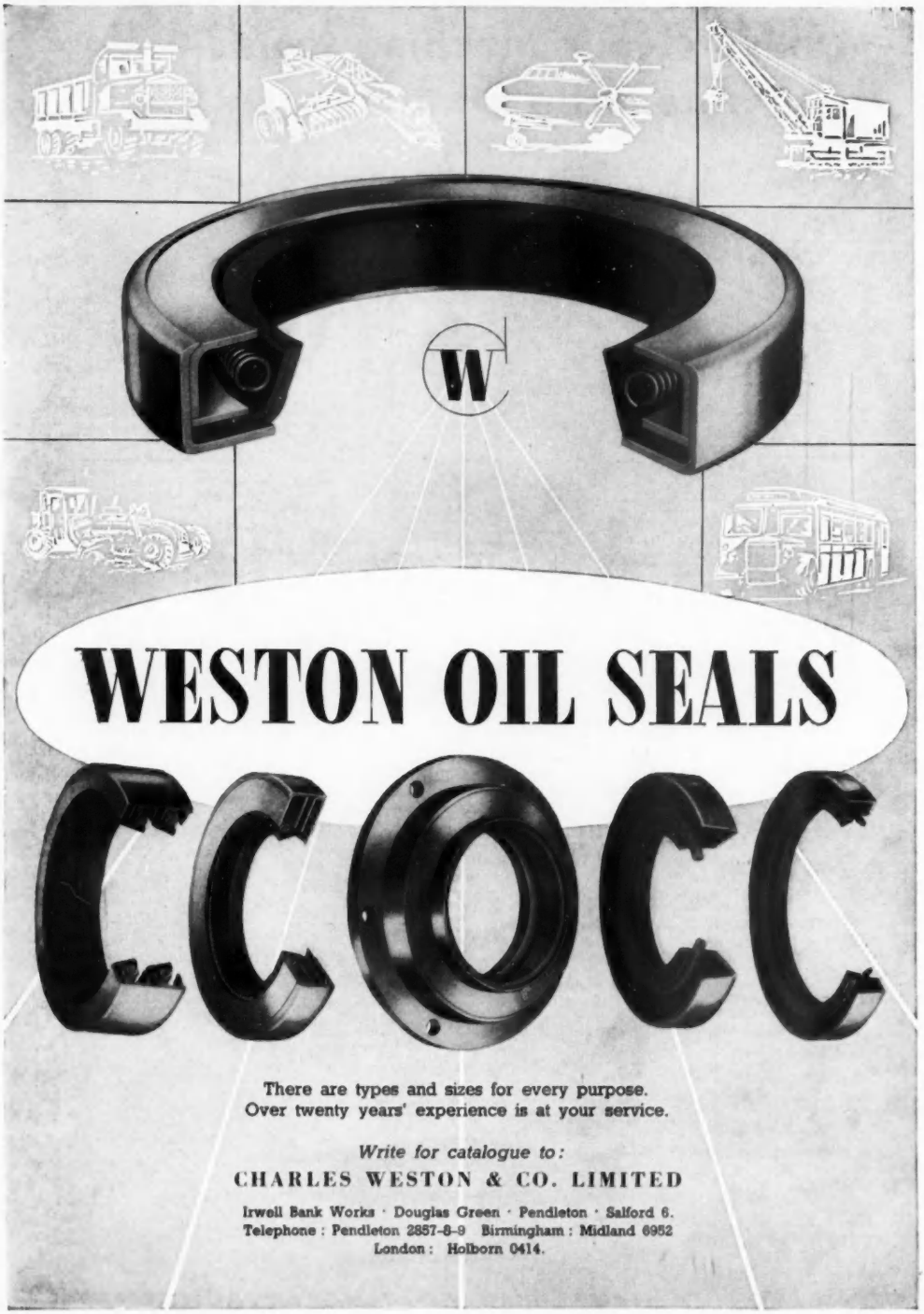
- *Setting-up, machining and inspection times are all greatly reduced.*
- *Initial cost is low compared with other systems.*
- *Suitable for internal copying.*
- *Force on stylus not exceeding 3lb*
- *Accuracy is independent of operator's skill.*

METROPOLITAN-VICKERS

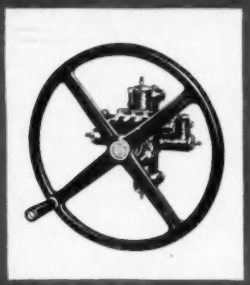
An A.E.I. Company

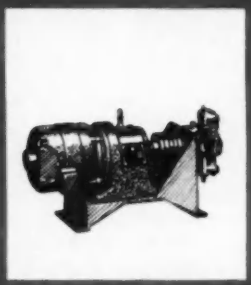
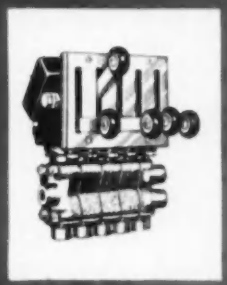
METROVICK HYDRAULIC COPYING ATTACHMENTS

G/V602

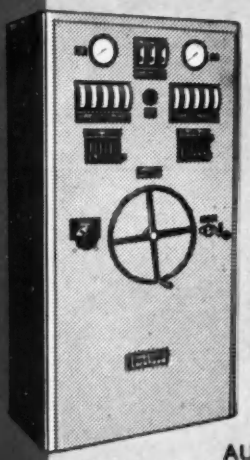

WESTON OIL SEALS
There are types and sizes for every purpose.
Over twenty years' experience is at your service.
Write for catalogue to:
CHARLES WESTON & CO. LIMITED
Irwell Bank Works · Douglas Green · Pendleton · Salford 6.
Telephone : Pendleton 2857-8-9 Birmingham : Midland 6952
London : Holborn 0414.

BACKED BY A QUARTER OF A CENTURY OF
LOCKHEED HIGH-PRECISION HYDRAULICS



UNITS THAT HAVE MADE HYDRAULIC HISTORY



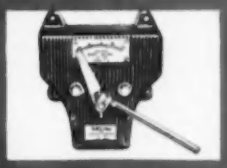
LOCKHEED specialized development on the problems of specific industries has led to the evolution of the many units which are ideal for their particular purposes.

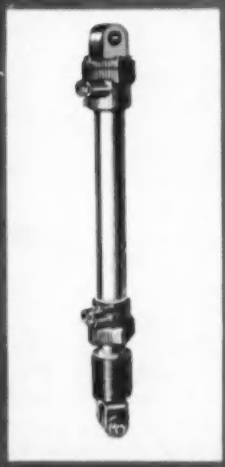
The units illustrated are typical of such specialization and represent the basis of the Lockheed Remote Control System. This was developed primarily for the control of Boiler Dampers and is to be found in the great majority of C.E.A. power stations.

It has also been widely adapted to many other industrial uses where the following features are of value:

1. Centralized control and individual selection of any number of control points.
2. Metered control of selected unit.
3. Instantaneous indication of position of selected unit.
4. Auto-locking of slave cylinder at desired position without need of retaining line pressure.
5. Hand operation in a simple system or as stand-by in the event of power failure.
6. Long life and reliable performance.
7. Low power consumption.

AUTOMOTIVE PRODUCTS COMPANY LIMITED
Shaw Road, Speke, Liverpool. Telephone: Hunts Cross 2121





Lockheed

REGD TRADE MARK

INDUSTRIAL HYDRAULICS

For further details please write for pamphlets, and kindly mention this journal.

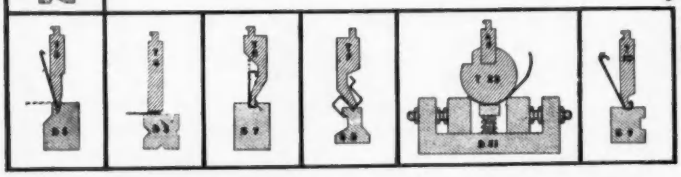
COMPLETE INSTALLATIONS BRITISH MADE OR INDIVIDUAL UNITS

BRONX PRESS BRAKE TOOL SERVICE

.... WE PROVIDE A HIGHLY SPECIALISED SERVICE FOR THE SUPPLY OF STANDARD AND SPECIAL TOOLS AND CARRY LARGE STOCKS OF FINISHED TOOLS ....

We have a Department that specialises in the design and manufacture of all types of tools. We guarantee quick service. Our design staff and planing machines exist for your benefit.

★ BENDING
★ FOLDING
★ PUNCHING



FREE ADVICE ON YOUR TOOLING PROBLEMS

BRONX ENGINEERING CO. LTD., LYE, WORCS. *Telephone: LYE 2307 & 2308*

LONDON & S. of ENGLAND AGENTS: W. E. Norton (Machine Tools) Ltd., Grosvenor Gdns. House, Grosvenor Gdns., London, S.W.1.—TATe Gallery 0633/4

-double production

WITH HEAP'S

2½" DOUBLE HEAD BOLT SCREWING MACHINES

Designed for really high output the HEAP'S Automatic 2½ in. Bolt Screwing Machines will cut either right or left hand threads (or both at the same time). The machine is fitted with our patent TANGENTIAL Die Heads, which open automatically when any predetermined length has been threaded.

Capacity: Bolts up to 2½ in. dia., pipes up to 2 in. dia. parallel or taper.

A complete range of sizes is available. We will gladly advise you as to the most suitable machine for your requirements. Catalogue free on request.

JOSHUA HEAP & CO., LTD.
ASHTON-UNDER-LYNE · ENGLAND

I gather Ransome & Marles have a substantial export trade?

Yes. Business overseas has been done for many years through agents and subsidiary companies. Among our biggest customers are many of the newly industrialised countries in Africa and the Far East—countries which are now equipping themselves with machinery at an enormous rate. We also export our bearings to the established industrial areas—to Europe and North America—where our products enjoy a long record of first-class service.

You have, of course, a worldwide network of agents to support this export trade?

We have indeed. Something like eighty agency offices throughout the world. We are concerned, mainly, with providing an unrivalled on-the-spot service for overseas industry. Firstly, we produce bearings that will stand up to arduous conditions of work in every climate. Secondly, local users are thoroughly informed about all the factors affecting the actual running of the bearings. Thirdly, the purchaser is safeguarded with after-sales service. These are our obligations to the foreign manufacturer. I think it is fair to say that we meet them very successfully, because we are constantly expanding our export business and shall continue to do so in the future.

RANSOME & MARLES BEARING CO. LTD • NEWARK-ON-TRENT • ENGLAND
TELEPHONE · NEWARK 456 AND TELEX 37-306

For SIMPLICITY of HANDLING, WIDE SPEED RANGE and VERSATILITY

Archdale 38" SENSITIVES

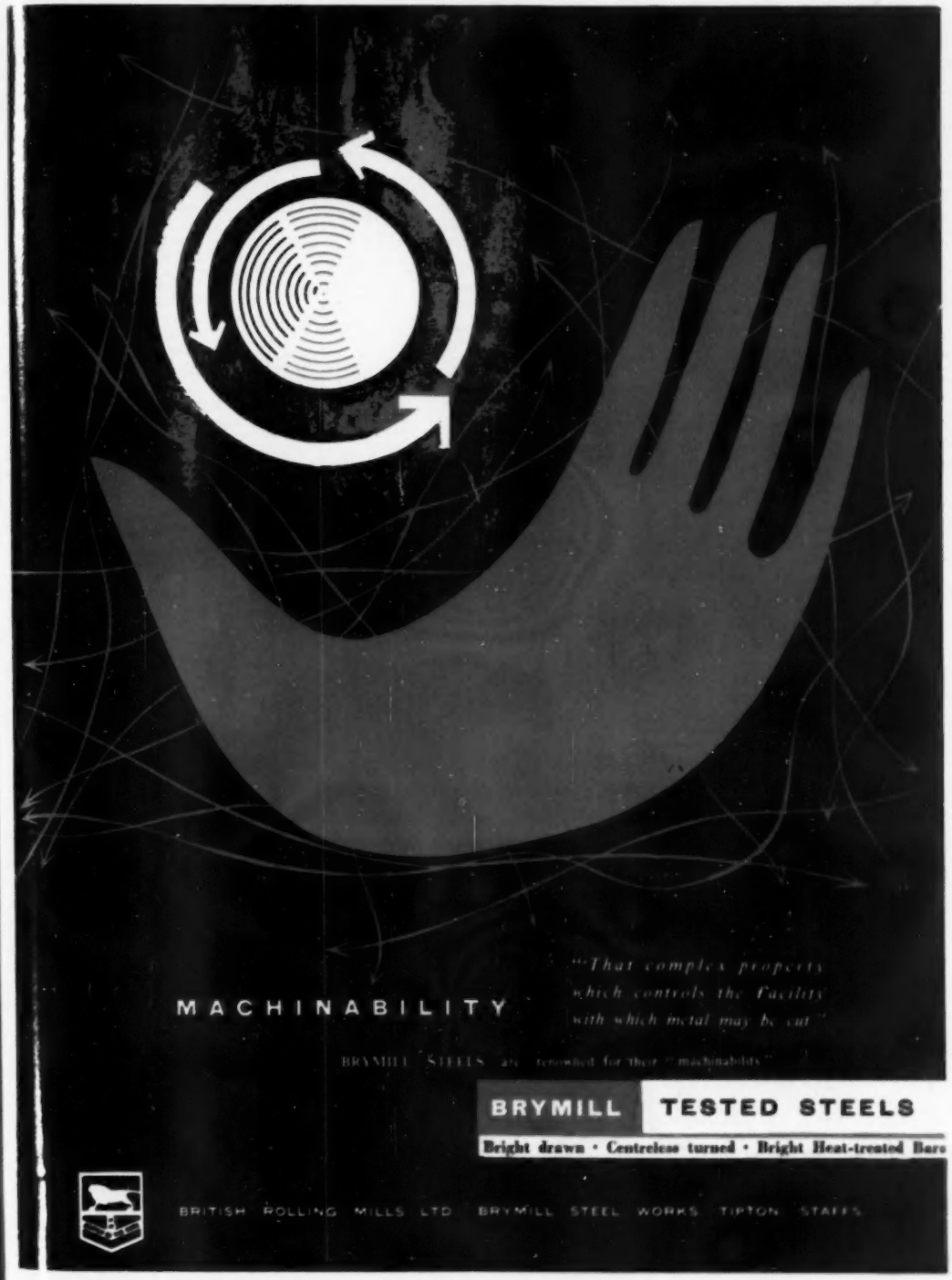
Here is the baby of the range, showing its paces on a nickel chrome steel cylinder head. The International Harvester Co. Ltd., of Doncaster, find the spot facing and tapping of 8" + ½" diameter holes reduced to child's play on the ARCHDALE 38". Jobs of this sort show the ease and speed of operation of these handy little machines to good advantage.

The 38" will drill up to 1" dia., in M.S. and has a spindle speed range of 129–1527 r.p.m. Write for details.

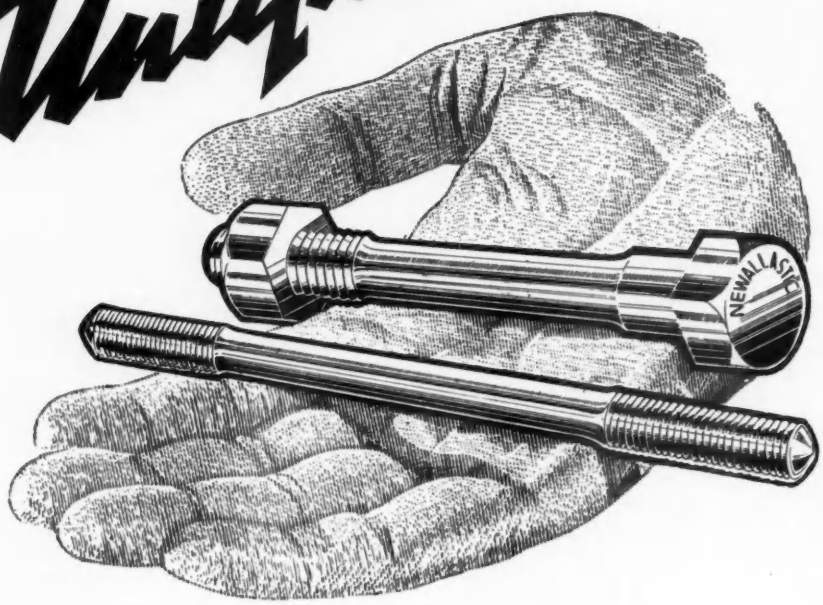
JAMES ARCHDALE & CO., LTD.

BIRMINGHAM 16 · SOLE SELLING AGENTS : ALFRED HERBERT LTD. COVENTRY

A member of the Staveley Coal & Iron Co. Ltd. Group.


MACHINABILITY
"That complex property which controls the facility with which metal may be cut"
BRYMILL STEELS are renowned for their "machinability"
BRYMILL TESTED STEELS
Bright drawn • Centreless turned • Bright Heat-treated Bars
BRITISH ROLLING MILLS LTD BRYMILL STEEL WORKS TIPTON STAFFS

Unique

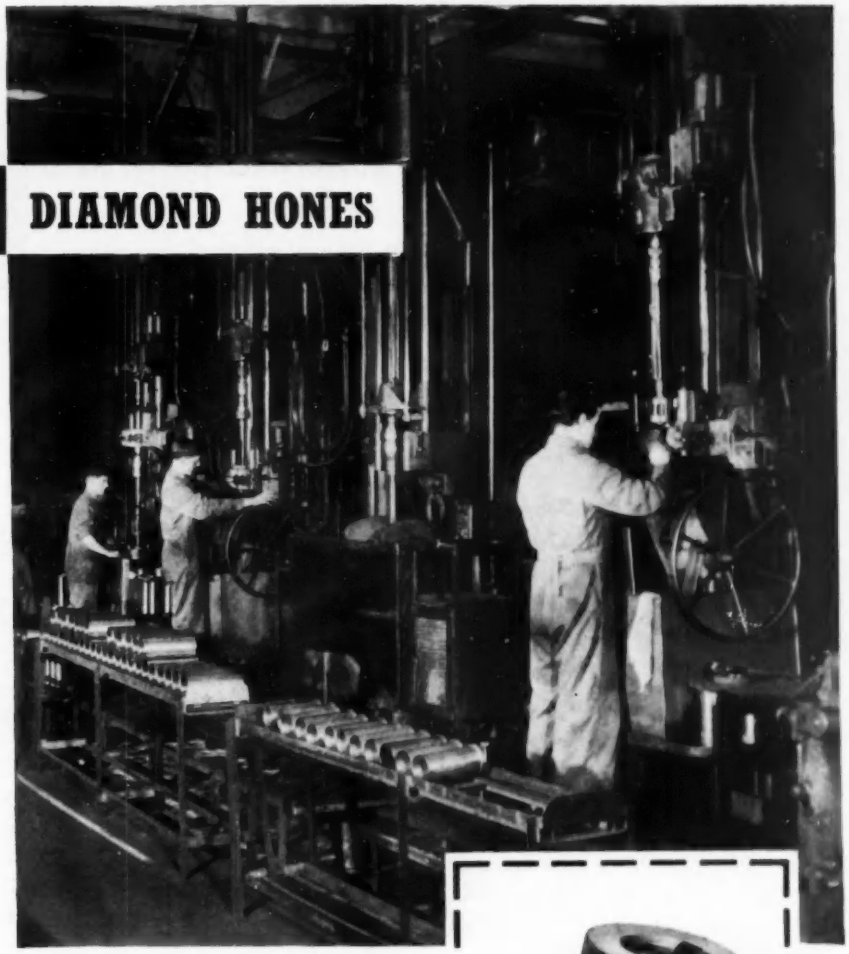


"Newallastic" bolts and studs have qualities which are absolutely unique. They have been tested by every known device, and have been proved to be stronger and more resistant to fatigue than bolts or studs made by the usual method.

C. P. Newall & Co., Ltd.

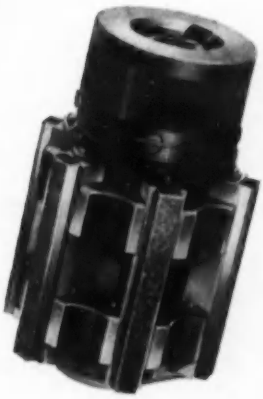
POSSILPARK GLASGOW · N

NEVEN **DIAMOND HONES**



(Photograph by kind permission of Leyland Motors Ltd.)

Neven hones are used by the leading engineering firms. The illustration shows our hones in use at Leyland Motors Limited



IDP

IMPREGNATED DIAMOND PRODUCTS LIMITED OF GLOUCESTER

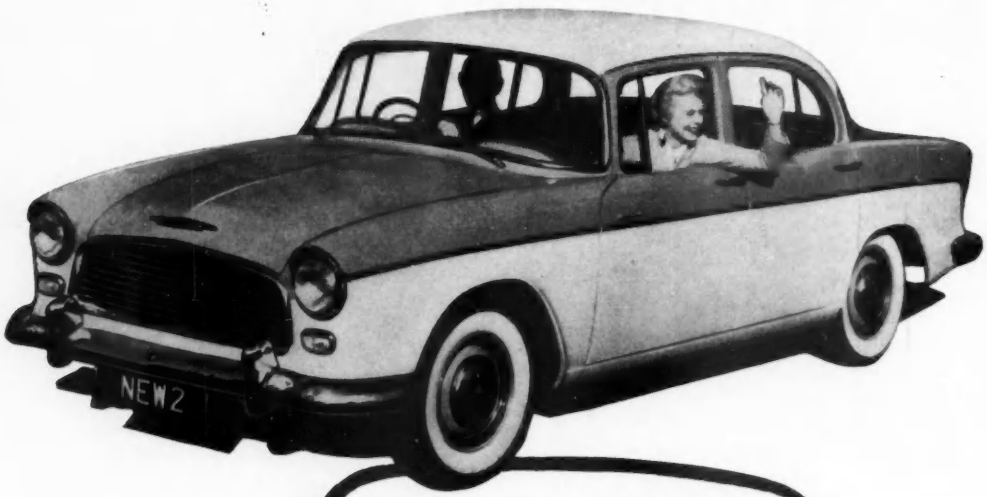
TELEPHONE 21164 (3 LINES)
TELEGRAMS IMPREG GLOUCESTER

Neven Diamond Tools Cut, Drill and Grind the Hardest Materials

Humber's greatest Hawk

Fine bodywork welded by Saturn-Hivolt

Surge Injector Welding Units



Notable always for the highest standard of bodywork. Humber recently announced their greatest 'Hawk'. In this, as in many previous models, Saturn-Hivolt Surge Injector Welding equipment and Saturn Argon are used for many of the important welding operations. Saturn cutting and welding equipment has, for many years, played a big part in industry. The new Saturn-Hivolt Argon Arc Welding Machines offer the finest welding of aluminium and its alloys and stainless steel. Let us show you the complete range supplied and maintained from our many branches throughout the country.

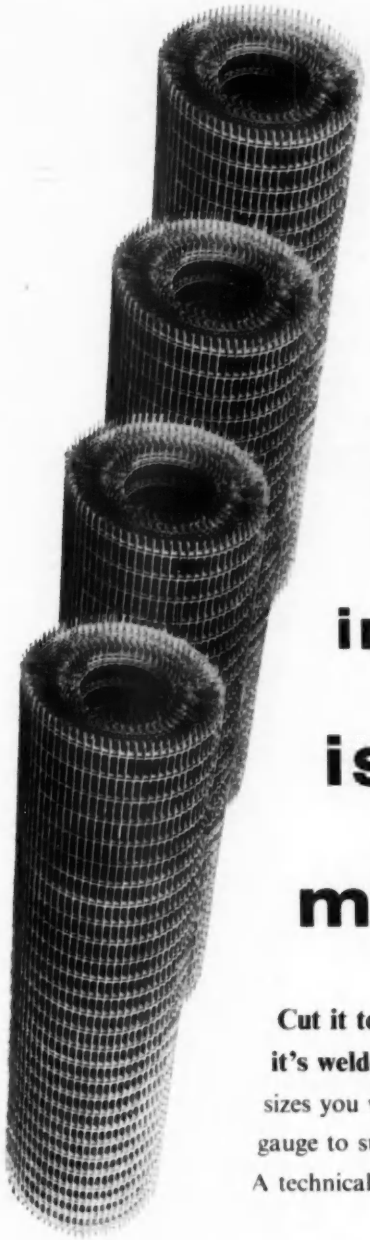
SATURN INDUSTRIAL GASES LTD

Saturn Works, Gordon Road, Southall, Middlesex Phone: Southall 5611

BRANCHES:

GLASGOW · BIRMINGHAM · MANCHESTER · SHEFFIELD

LYMINGTON · SUNDERLAND · THORNABY-ON-TEES



For the fabrication of wire products

Weldmesh

in rolls or sheets is an ideal material

Cut it to the shape you want — it holds together because it's welded together. In the Weldmesh list of standard sizes you will find a mesh size and wire gauge to suit every purpose.
A technical service is available to handle any problems.

Weldmesh is a registered trade name and is supplied direct to users by the sole manufacturers:

THE B.R.C. ENGINEERING CO. LTD., STAFFORD

London, Birmingham, Bristol, Leeds, Leicester, Liverpool, Manchester, Newcastle, Cardiff, Glasgow, Dublin, Belfast, Bulawayo, Calcutta, Johannesburg, Singapore, Vancouver. *Export Sales: 54 Grosvenor Street, London W.1*

tools from HALLMAC

means first class tools

and **first class** delivery service always ! They include the famous **MACROME** Treated Tools for longer, more economical life and a wide range of tools by leading makers among whom are the following :

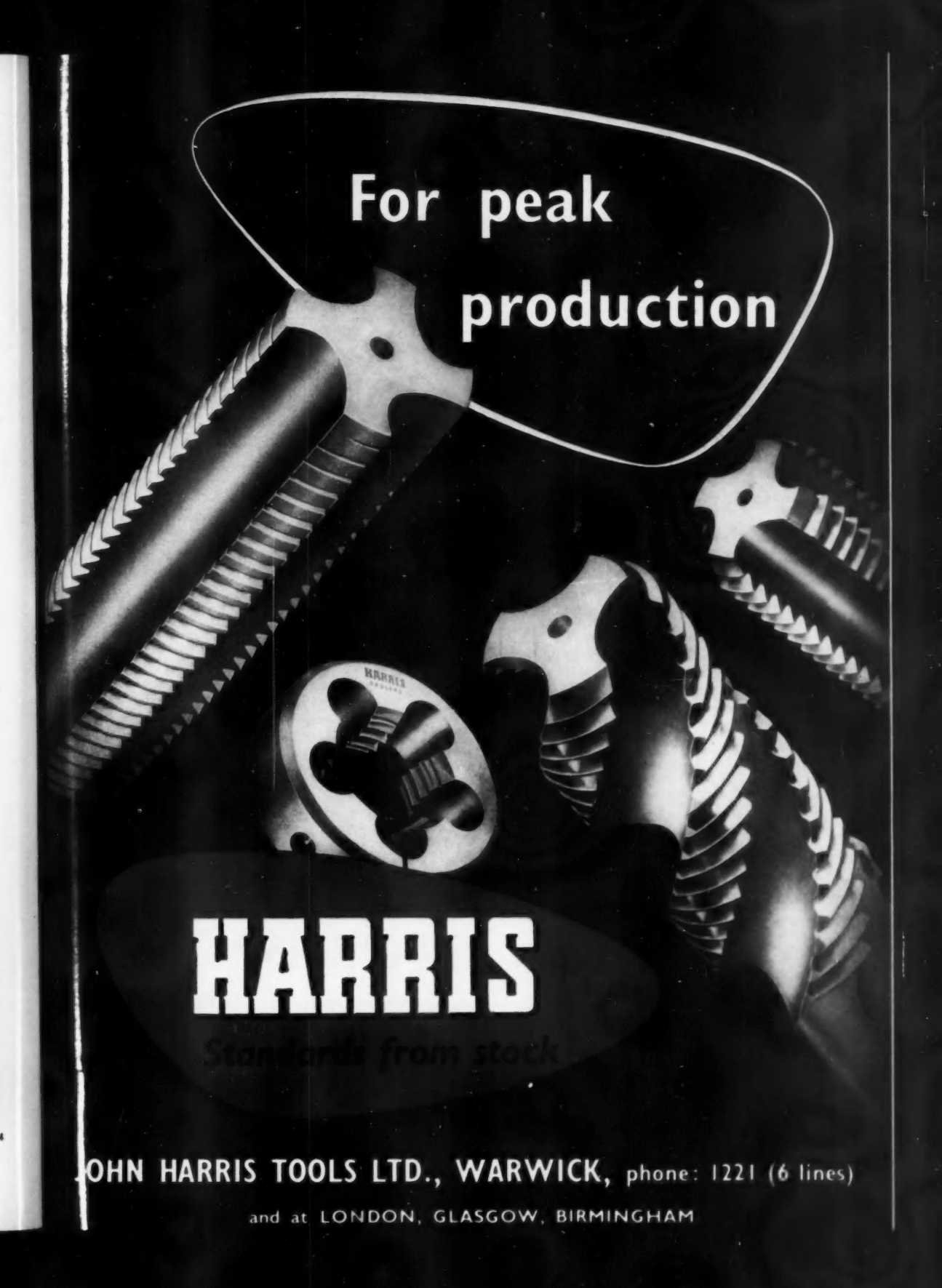
EDGAR ALLEN & CO LIMITED
John Bedford & Sons, Limited
CARDINAL — The Brooke Tool Manufacturing Co Ltd
Cutanit — William Jessop & Sons Ltd
DORMER — The Sheffield Twist Drill & Steel Co Ltd
Eclipse — James Neill & Co (Sheffield) Ltd
ENGLISH STEEL TOOL CORPORATION
JOHN HARRIS TOOLS LTD
ALFRED HERBERT LTD
CE JOHANSSON LTD
SPEEDICUT — Firth Brown Tools Ltd
WODEN — Woden Tools Ltd
SUMMIT — Joseph Thompson (Sheffield) Ltd
SUPER SPEED — Slack Sellars & Co Ltd
Wolf — Electric Tools Ltd

For your every need Standard or Special

in **ENGINEERS' SMALL TOOLS**
HAND & POWER TOOLS
MACROME TREATED TOOLS

Write to **HALLMAC TOOLS** LIMITED Head Office and Works:
G.P.O. Box No. 39, Macrome Road, Wolverhampton
Telephone 52001 (5 lines)
or to one of our branches in London, Manchester or Glasgow
or contact your nearest representative
Sales managers or the Hand Tool Division of the Bren Manufacturing Company

JW.Ad 4054



JOHN HARRIS TOOLS LTD., WARWICK, phone: 1221 (6 lines)

and at LONDON, GLASGOW, BIRMINGHAM

Switch from this—

to this

and step up production . . .

For working within close limits, an Anglepoise is simply indispensable. However good a worker and his eyes may be, he must see the job. This applies in all fine work, drilling, assembling, etc., where instantly adjustable close-to-the-job lighting is a sheer necessity.

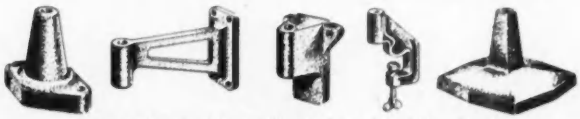
ANGLEPOISE throws a clear, concentrated light right on and into the work, not in the operator's eyes, follows the job from any position or angle, degree by degree, at a finger-touch, and 'stays put' in any required position—and out of the way when not needed. It needs only a low-powered bulb for high-class results—a big saving on the lighting bill (it can be supplied with a small shade for low voltage systems). Why not learn more about this fine lamp by sending for Booklet E.D.?

TERRY Anglepoise LAMP

Regd.

Sole Makers: HERBERT TERRY & SONS LTD · REDDITCH · WORCESTERSHIRE

***A SUGGESTION FOR MACHINE MANUFACTURERS:—**
Why not fit your products with Anglepoise? We will submit samples on approval.



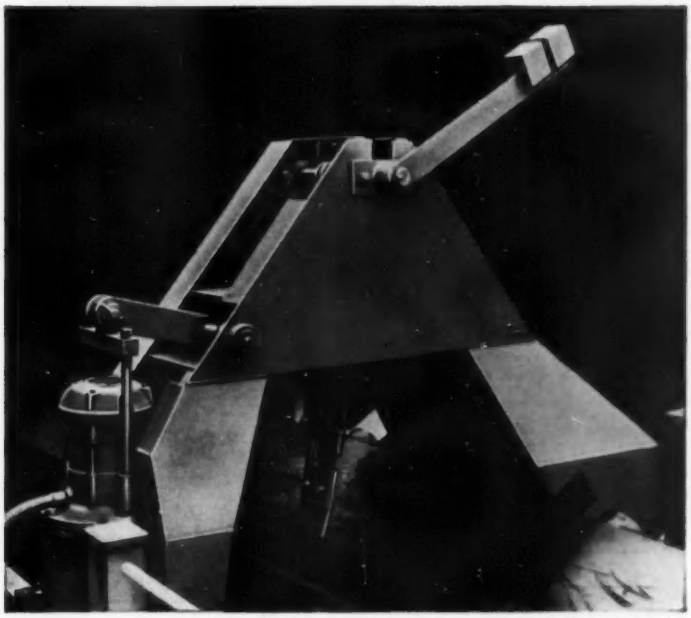
Some of the alternative bases for all models

HT208

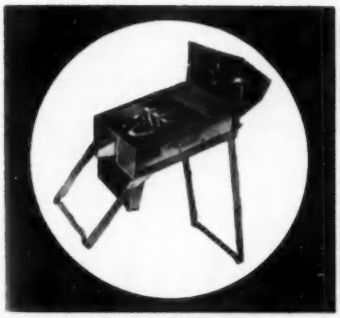
Materials sampling stage by stage

WITH IC LABORATORY EQUIPMENT

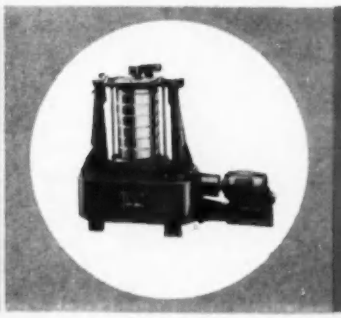
The need for accurate sampling of many bulk materials on belt conveyor installations is met by the IC Pollock Sampler. Simple, robust, and easy to maintain, its reliable performance has been proved by prolonged power station service, and it fully conforms to B.S. limits of accuracy. The sampler can be readily applied to new or existing belt conveyor installations with minimum alteration to lay-out of plant. It is part of an extensive range of IC Laboratory Equipment for sampling, sifting and grinding through every stage of materials testing.



The IC POLLOCK Sampler



The TYLER Sample Reducer
reduces a large sample to a representative sixteenth part in only one operation. A 1-lb. sample for sieve tests can be obtained from 256 lb. of material with only two reductions.



The RO-TAP Sieve Shaker
provides a uniform mechanical shaking method from test to test. It handles up to thirteen 8-in diameter sieves in a single operation.

The RAYMOND Laboratory Mill
carries out experimental grinding of non-abrasive dry materials in batches of a few ounces to several pounds at a time. Five interchangeable screens provided for varying degrees of fineness.

Send for full details

OTHER LABORATORY EQUIPMENT INCLUDES: Elutriators, ROVAC Filter, TY-LAB Tester

IC

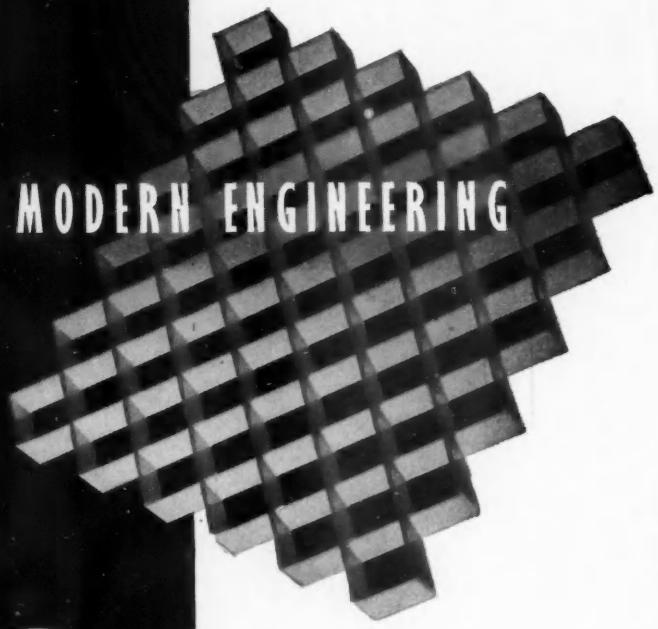
INTERNATIONAL COMBUSTION PRODUCTS LIMITED

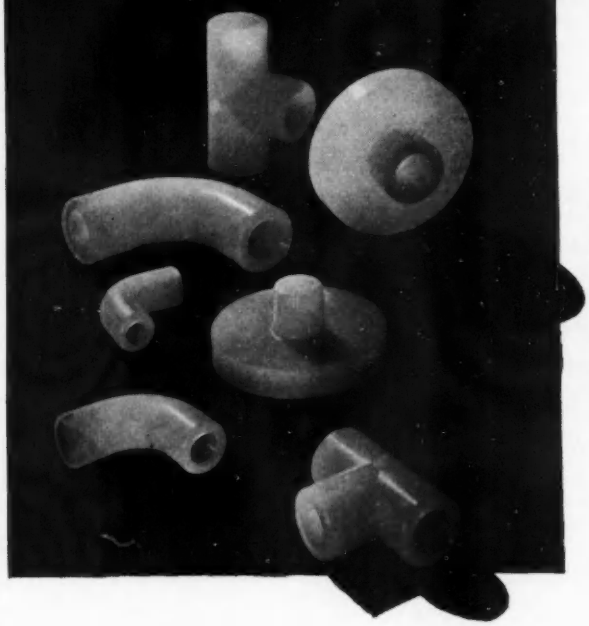
London Office: Nineteen Woburn Place, W.C.1 Tel: Terminus 2833 Works: Derby, England

Spa

PLASTICS for MODERN ENGINEERING

INJECTION MOULDING
up to 32 ozs
in
CELLULOSE ACETATE
POLYTHENE DIAKON
NYLON POLYSTYRENE





. . . in all types of industry

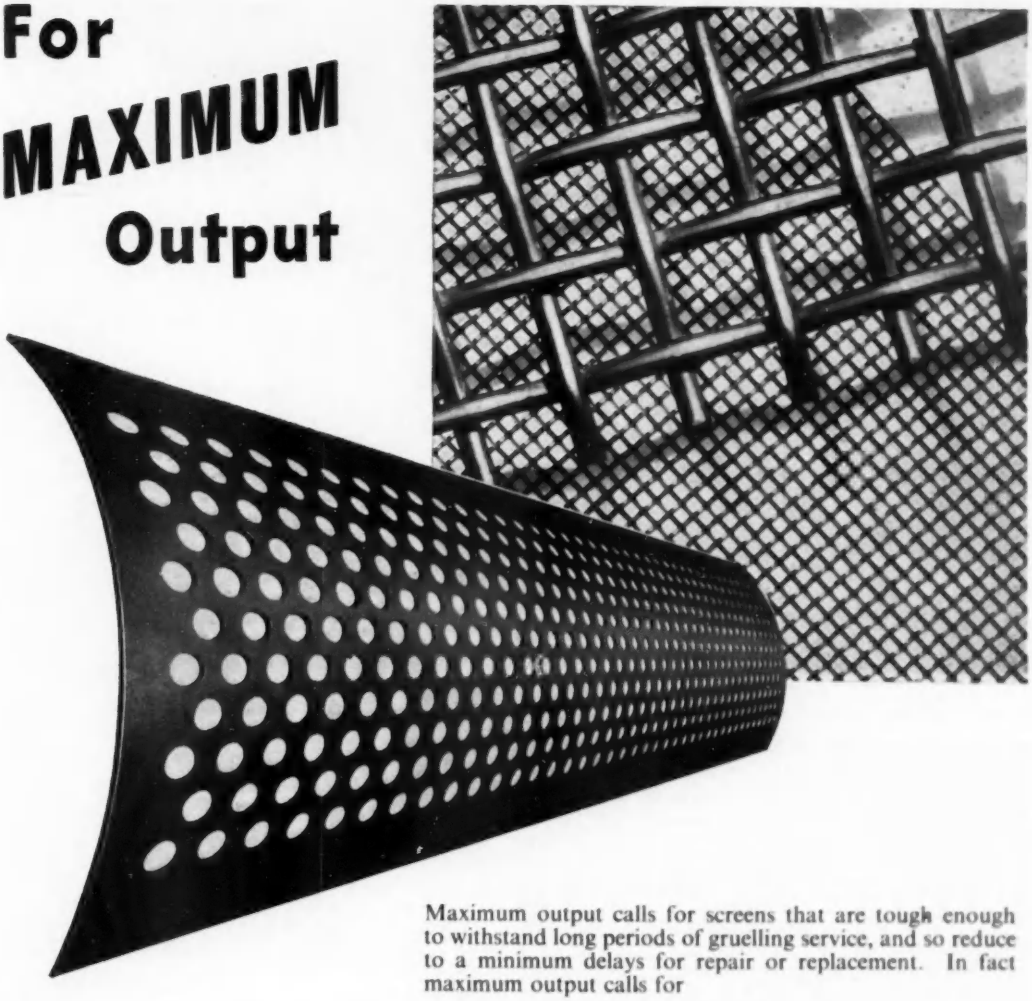
. . . from gears, bearings and grommets to flanges, control knobs and O-rings there is a huge range of components which progressive engineers will want in plastics. The advantages are chiefly in price, durability, high strength/weight ratio and resistance to abrasion; in Electrical Engineering, low permittivity, high dielectric strength, low power factor—even under U.H.F. conditions.

Our technical moulding services are at your disposal. We welcome your enquiries.

Spa
ENGLAND

SPA PLASTICS (Division of Spa Brushes Ltd.) **CHESHAM · BUCKS · ENGLAND**
Telephone: CHESHAM 81200 (P.B.X.) *Telegrams:* FREEMBRUSH, CHESHAM

For MAXIMUM Output



Maximum output calls for screens that are tough enough to withstand long periods of gruelling service, and so reduce to a minimum delays for repair or replacement. In fact maximum output calls for

'HARCO' PERFORATED METAL AND WIREWORK SCREENS

Please ask for Catalogues Nos. ED858 and ED926

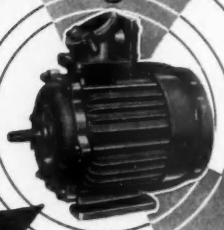
Supplied as flat or curved plates, or as complete screens to specification, in a wide range of gauge, mesh and pattern for every screening, sorting or sizing requirement.

Harvey

G. A. HARVEY & CO. (LONDON) LTD.
Woolwich Road, London, S.E.7. GREenwich 3232 (22 lines)

R.P.M or R.P.A ?

Revolutions per minute or revolutions per annum ? There you have the vital difference between ordinary electric motors and those made by EPE. Thousands of EPE electric motors are running at the rate of over 1000,000,000 revs. a year—unfailingly —year in, year out ! Unusual ? Not a bit. EPE electric motor users take this sort of service for granted. Next time you're buying electric motors remember it pays to specify EPE—to be sure.



ELECTRICAL POWER ENGINEERING CO. (B'HAM) LTD.
BROMFORD LANE BIRMINGHAM 8
Phone: STEchford 2261 'Grams: Torque Phone: Birmingham

LONDON OFFICE: 421 GRAND BUILDINGS, TRAFALGAR SQ., LONDON, W.C.2.
Phone: Whitehall 5643 & 7963

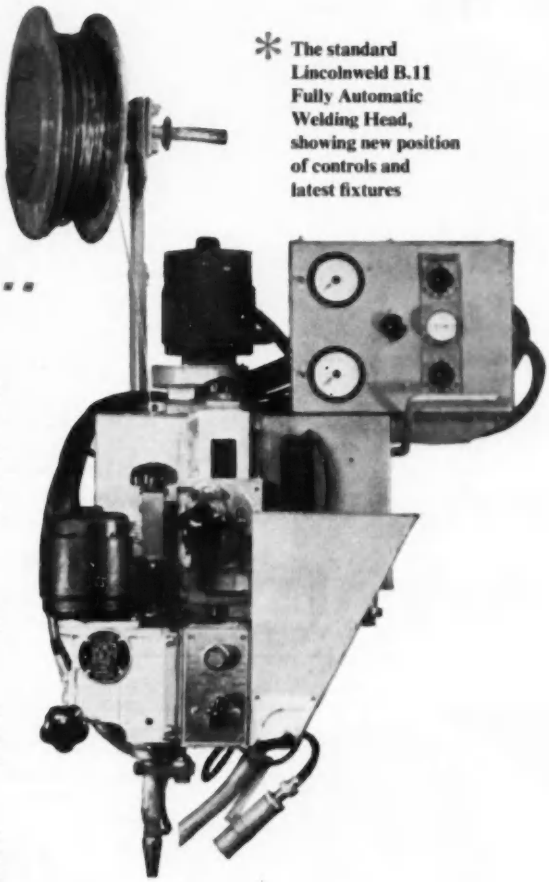
By kind permission of Messrs. John Thompson Ltd., Wolverhampton

GIBBONS

Oil fired Bogie Type Stress Relieving and Annealing Furnace

GIBBONS BROTHERS LTD · *P.O. BOX 19, DIBDALE · DUDLEY WORCS.*
TELEGRAMS · "GIBBONS, DUDLEY" *TELEPHONE · DUDLEY 3141*

Better Welding *AUTOMATICALLY...*



✻ **The standard Lincolnweld B.11 Fully Automatic Welding Head, showing new position of controls and latest fixtures**

The famous Lincolnweld Fully Automatic Submerged Arc Process has been further improved to give easier, faster and more efficient operation. Listed below are some of the major features, specially designed to meet today's high-speed production methods.

✻ **All controls face the operator. The control station is hinged to the flux hopper for easy access to the wire feed mechanism.**

✻ **Standard or Wide Range Speed Control Units available to give travel speeds of 10″-60″ per min. in 3:1 ratios (standard) or 5″-200″ per min. in 20:1 ratios (Wide Range Control Unit).**

✻ **New slide mechanism enables welding head to be moved both vertically and horizontally. Wire feed gear box, control station, nozzle and flux hopper can be rotated through 90° for the welding of circumferential seams.**

✻ **New compact wire guide nozzle, with the correct volume of flux being ensured by flux feed valve and a shroud covering nozzle and feed tube to concentrate flux shield.**

✻ **Greater stability ensured by new position of wire reel carrying stand, with extra idlers and rollers on beam traverse (B.11 only).**

✻ **Point of welding accurately illuminated by special guide light.**

with the latest

LINCOLNWELD

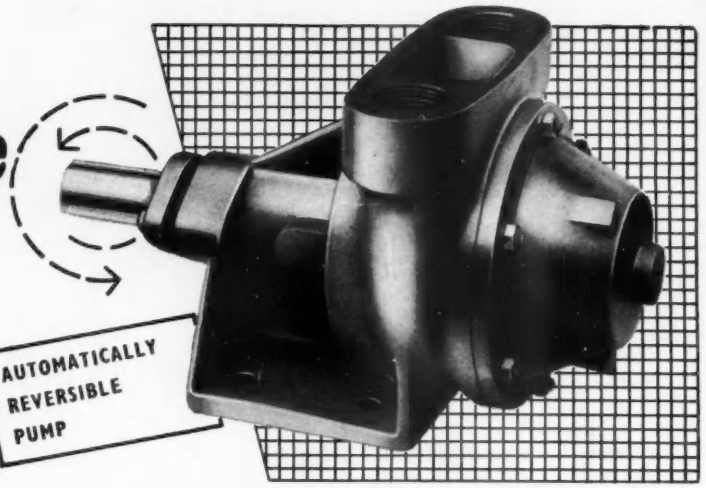
For further details of the full Lincolnweld range and how the Lincolnweld Process can be adapted to suit your requirements, please write today to:

THE AUTOMATICS DIVISION

LINCOLN ELECTRIC CO LTD · WELWYN GARDEN CITY · HERTFORDSHIRE · WELWYN GARDEN 920/4, 4581/5

Forward or Reverse Drive

Automatically maintains uniform direction of flow irrespective of the driving shaft rotation. Rotary, valveless and self-priming in capacities from 80 g.p.h. to 2,300 g.p.h. these pumps are suitable for most non-corrosive liquids up to 300° F of practically any viscosity. Foot or flange mounting.



this pump keeps on working

MEASUREMENT LIMITED

MANUFACTURERS OF LIQUID METERS, ROTOPLUNGE PUMPS AND CONTROL APPARATUS

TAMESIDE WORKS · DOBCROSS · NEAR OLDHAM

Telephone: Delph 424 (5 lines) Telegrams: SUPERMETER, Dobcross

A Member of The Parkinson Cowan Group

This **MYFORD MACHINE TOOLS**

CYLINDRICAL GRINDER

is worth looking into!

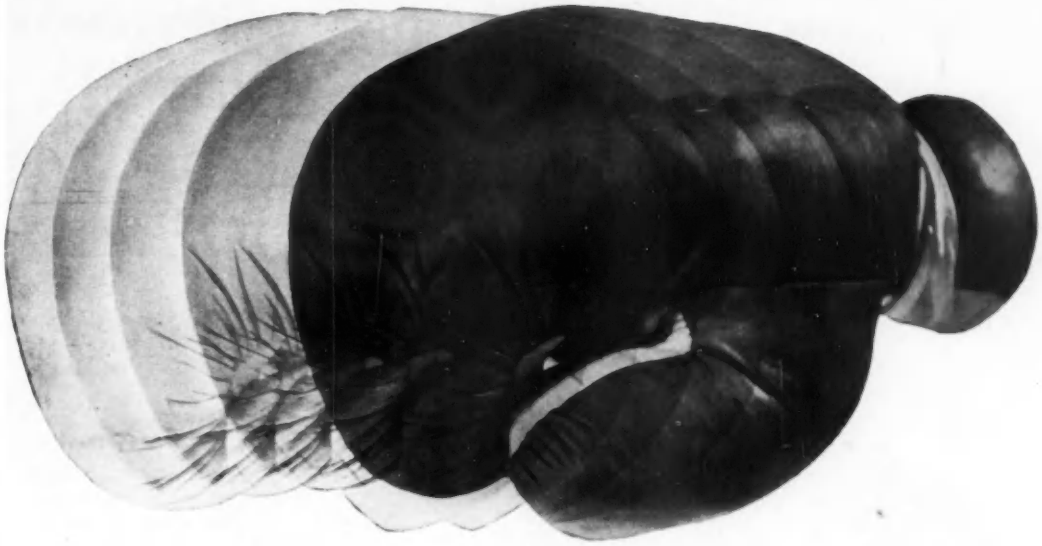
MG 12

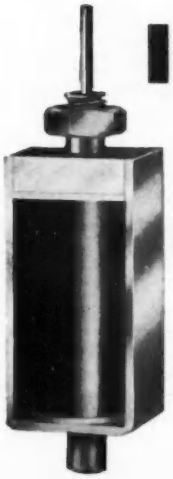
GRINDING CAPACITY 3⅝in. dia. × 12 in. long
SWING 5 in. dia.
WHEEL SIZE 10 × 1 × 3 in. bore
WHEEL SPINDLE SPEEDS 2200 & 2500 r.p.m.
WORK SPEEDS (12) ranging from 75 to 780

Here is a machine which will economically grind either small or large batches or individual workpieces. It features a sensitive wheelfeed mechanism graduated to 0·000025 in.; an ample supply of coolant with effective filtration; retractable dead stop for carriage movement, and a readily interchangeable cartridge-type wheel spindle.

Equipment available for :—
Internal Grinding, Centre Pointing, Angular and Radius Wheel Dressing. Also Chucks, Collets, Faceplate.

Myford ENGINEERING Co. Ltd.
BEESTON · NOTTINGHAM · TEL. 25-4222





1000 times a minute!

The Varley S.M.O. solenoid is the first of a range of miniature solenoids being developed for the electronic and accounting machine industries.

It can operate about 1000 times a minute through $\frac{1}{8}$ in.

Varley make Solenoids of all shapes and sizes to push or pull anything from ounces to thousands of pounds.

If you need to push, pull, press, prod or punch—*by remote control*—investigate the applications of Varley Solenoids.

They are 100% British in design and manufacture.

Varley
REGD. TRADE MARK
WOOLWICH 1422

For full details of Varley Solenoids send this coupon

OLIVER PELL CONTROL LTD.
CAMBRIDGE ROW, WOOLWICH, S.E.18

☐ Please send me illustrated booklet "VARLEY SOLENOIDS"
☐ Please arrange for a technical representative to call on me

NAME _____

COMPANY _____

ADDRESS _____

_____ E.D.

OLIVER PELL CONTROL LIMITED

This modern machine-age world centres on the small but vital key and taper pin

make sure you fit

FREMO
TRADE MARK

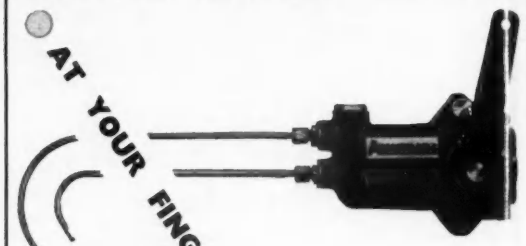
THE WORLD'S BEST

FREDERICK MOUNTFORD (B'HAM) LTD.

FREMO WORKS • MOSELEY STREET • BIRMINGHAM 5
Telephone: MIDland 7984 PBX Telegrams: FREMO, BIRMINGHAM

POSITIVE REMOTE CONTROL

AT YOUR FINGER TIPS



Wherever the application of an efficient positive remote control system is required the ARMSTRONG Unit provides a simple effective answer. Easy to install, rust-proof, permanently self-lubricated and temperature corrected, neither the 'Slave' or 'Master' units need maintenance. Amongst innumerable applications, flue damper controls, built in systems for Machinery Controls and Motions, remote gear shift operations, jig latching and valve control, etc., are typical.

Full information gladly supplied

ARMSTRONG

Regd. Trade Mark

REMOTE CONTROL UNIT

ARMSTRONG PATENTS COMPANY LTD.

EASTGATE . BEVERLEY . YORKSHIRE

induction heating

let us prove it first...

No two applications of Induction Heating are quite the same. That is why we offer to demonstrate your job being done on our premises before you buy Delapena equipment. This is the work of our unique Applications Department, which can demonstrate many advantages of Induction Heating. For example:

HARDENING: Ultra-rapid and highly localised heating eliminates distortion, cuts rejects, minimises scaling and resultant machining.

BRAZING & SOLDERING: Speedy operation; clean, 100% joints; consistency of performance; close control over quantities of the soldering medium; easy operation by unskilled personnel—these are just a few of the major advantages which Induction Heating can offer in repeat brazing and soldering work.

It is not always evident to anyone but an Induction Heating specialist that this method of production is appropriate in a particular instance. Please ask our advice. If Induction Heating is the answer to your problems, we will tell you—and prove it to you first.

Delapena **precision induction heating equipment**

valve generator, motor generator and vacuum melting equipments

Please send further details and literature on Induction Heating

_____

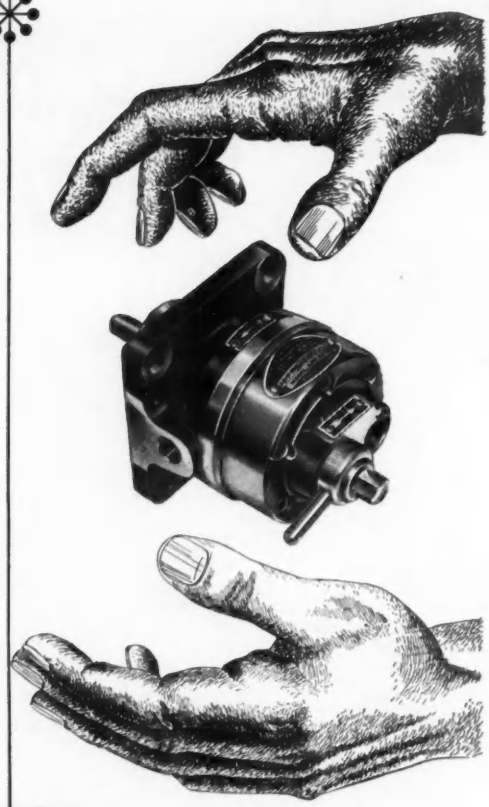
_____

_____

Delapena & Son., Ltd. Zona Works · Cheltenham · England · Tel: Cheltenham 56341

Manufacturers of Induction Heating and Precision Honing Equipment

We shall be delighted to PROVE it to you



More accurate than human skill itself

Hydraulic Control of motion

Paradoxically, the product of human skill is more accurate than human skill itself. This is particularly so in the case of Savery Hydraulic Pumps. Countless thousands of Savery Pumps are in use throughout the world working with precision that neither human skill nor other means can match. Next time you're considering control of motion remember Savery Hydraulic Pumps first.

Savery Pumps can be supplied with fixed or variable delivery.

FOR FURTHER DETAILS OF

SAVERY HYDRAULIC PUMPS

WRITE TO

THOMAS SAVERY PUMPS LIMITED

BRACEBRIDGE STREET · BIRMINGHAM 6 · TEL: ASTon Cross 1316-7

EDCC plant for frequency stabilisation

For maintaining a continuously controlled frequency of A.C. supply for perfect transmission. Frequency stabilisers and ancillary control gear have recently been supplied to the B.B.C. The output available is 17.5 kVA and the equipment also includes an automatic voltage regulator.

Illustration shows one of six similar sets recently supplied to the B.B.C.

Energy shaped to industry

ELECTRO DYNAMIC CONSTRUCTION CO LTD

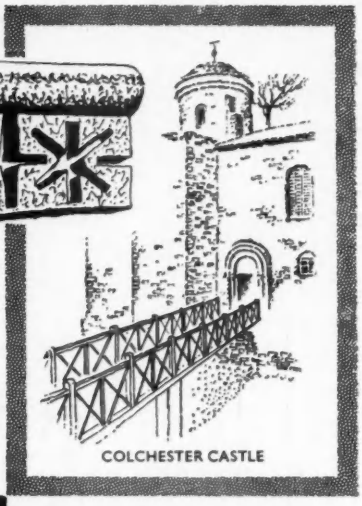
ST. MARY CRAY · KENT

Control Gear Division: Bridgwater, Somerset. Tel: Bridgwater 2882. Glasgow Office: 40 Houldsworth St., C.3. Tel: Central 2620

STEEL KEY TO INDUSTRY

No. 23

Found at Colchester, this key of early 15th or 16th century was designed for hard work. The handle allows for three fingers and denotes that an enormous amount of pressure must have been used before the key was effective. It can easily be imagined that this was the "key to the castle".



COLCHESTER CASTLE

The development of steel made possible the growth of civilisation itself. For steel is the key to the good things of life as well as to the necessities; as essential to the maker of the precision watch as to the bridge-builder. Hallamshire high-grade alloy and carbon steels serve a multitude of industries in many ways.

Manufacturers of:
ALLOY & SPECIAL CARBON STEELS
BARS · SHEETS · PLATES · WIRE RODS

Hallamsteel

THE HALLAMSHIRE STEEL & FILE CO. LTD. SHEFFIELD, 3, ENGLAND.
Telephone: Sheffield 24304 (7 lines).
Telegrams: Hallamsteel, Sheffield.

CARDINAL DRILL CHUCKS

W.M. SPENCER SHEFFIELD ENGINEERS FILES

PRECISION BURNERD CHUCKS

Pratt Chucks

Wolf ELECTRIC TOOLS

Eclipse MAGNETIC CHUCKS & ENGINEERS TOOLS

ELGAR 4000
EXT. 11 & 12

M&W PRECISION TOOLS

PRESTO DRILLS, REAMERS, & SCREWING TACKLE

CARL ZEISS JENA

DORMER DRILLS & REAMERS

RECORD VICES, BOLT CROPPERS & PIPE WRENCHES

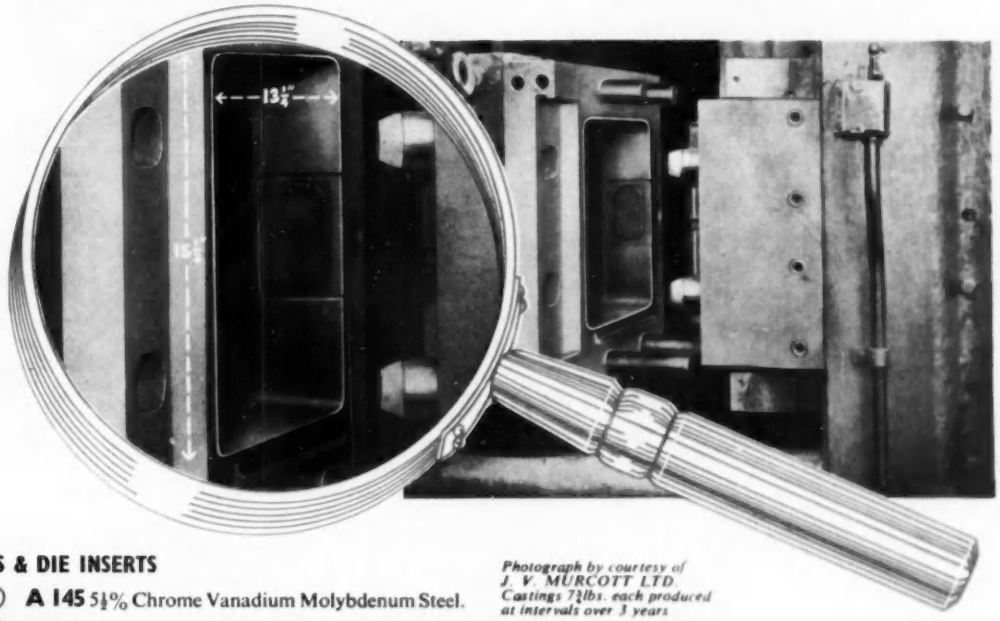
FOR ALL ENGINEERS TOOLS · MACHINE TOOL ACCESSORIES

Selson MACHINE TOOLS

The Selson Machine Tool Co. Ltd
41-45 MINERVA ROAD, LONDON, N.W.10

THE 600 GROUP

KE SPECIAL STEELS for die casting dies



Photograph by courtesy of J. V. MURCOTT LTD. Castings 7¼lbs. each produced at intervals over 3 years

DIES & DIE INSERTS

(KE) **A 145** 5½% Chrome Vanadium Molybdenum Steel.

(KE) **X 369** 5½% Chrome Tungsten Molybdenum Steel.

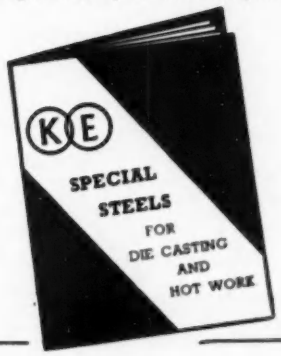
(KE) **896** Medium Carbon Chrome Vanadium Steel.

Supplied in ultrasonically tested forged blocks and black bars of square, round and rectangular sections.

DIE CORES

(KE) LOCK **237** 18% Tungsten Vanadium High Speed Steel or the same quality of steel as that used for the die. Supplied centreless ground to precision limits, in lengths.

This booklet, giving greater detail, is available free on request.



EJECTOR PINS

(KE) **896** Medium Carbon Chrome Vanadium Steel and other types.

Supplied centreless ground and in the annealed condition, suitable for upsetting of the ends.

UNCOATED WELDING FILLER RODS

(KE) **A 145** 5½% Chrome Vanadium Molybdenum Steel.

(KE) **X 369** 5½% Chrome Tungsten Molybdenum Steel.

5/32" diameter material, in 3 feet lengths, available from stock.

Especially suitable for atomic welding under hydrogen.

KAYSER ELLISON & CO. LTD

ESTABLISHED 1825

CARLISLE STEEL WORKS · SHEFFIELD

Midland Stock Warehouse

Station Road, Coleshill, Birmingham. Tel. Coleshill 2041/2

if you could take an X-ray photograph

From ½lb. to ¼ ton.
Grey Iron Castings up to 17 tons B.S.S. 1452.

You will see that the "Starcast" smooth finish is more than skin deep, in fact, quality is consistent throughout. Shrewd buyers specify "Starcast" for a really good casting at a reasonable price.

MACHINE SHOP SERVICE
Our modern machine shop service including gear cutting and horizontal boring will economically speed your production programme (A.I.D. approved).

"STARCAST"
REGISTERED TRADE MARK

ACCURATE CASTINGS IN
GREY IRON . BRASS . GUNMETAL
ALUM . BRONZE . ALUMINIUM
ALLOY (STAND & DIE)

Our Representatives are ready to visit you anytime. Write to:—

THE STAR FOUNDRY LIMITED
BILSTON, STAFFS.

Telephone: BILSTON 41474/6

HERMETIC RUBBER PRODUCTIONS

To meet every need of Modern Industry in current production or future development.

Our many years of experience as manufacturers in Natural or Synthetic Rubber are at your disposal.

Moulded Products of all kinds, Flexible Fabric Coupling Discs, Extruded Rubber Sections, Radiator Hose (Canvas Inserted), Mud and Stone Deflectors, Mats and Matting.

Est: 1895

HERMETIC RUBBER CO. LTD.

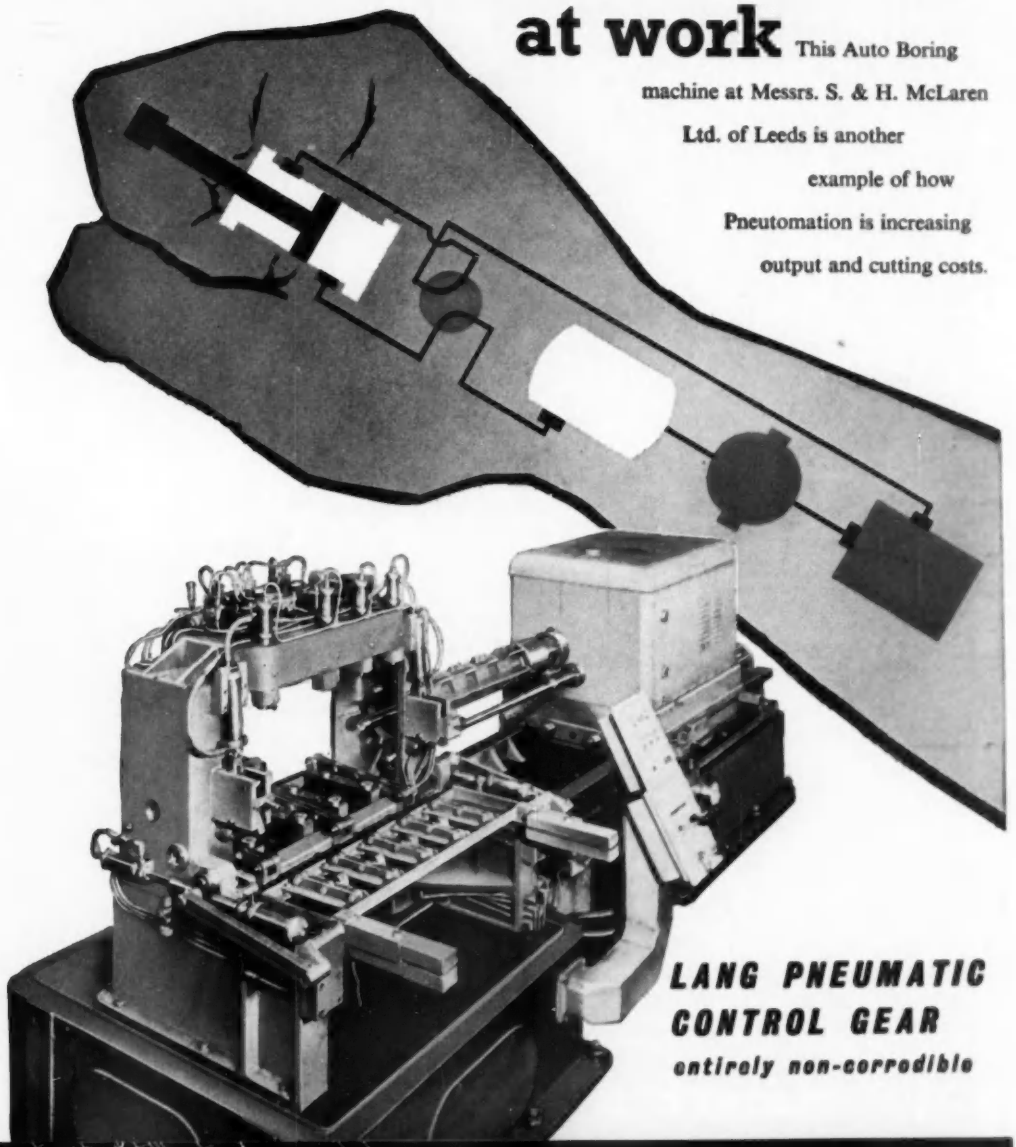
RYLAND STREET . BIRMINGHAM, 16

Telephone: Edgbaston 0983/4
Grams: Hermetic Birmingham

PNEUTOMATION

Registered Trade Mark

at work This Auto Boring machine at Messrs. S. & H. McLaren Ltd. of Leeds is another example of how Pneutomation is increasing output and cutting costs.



LANG PNEUMATIC CONTROL GEAR
entirely non-corrodible

Plan with
LANG PNEUMATIC LTD
VICTORY WORKS BIRMINGHAM ROAD WOLVERHAMPTON Tel 25221 2 3

P.1209

serving industry and the community

As members of a community, we are dependant on one another. Our whole organisation is based on this simple fact.
The renowned M & C Sales and Technical service is our contribution to the urgent day-to-day needs of British Industry.

Photograph by courtesy of Messrs. British Olivetti Limited

Monks & Crane Ltd

BRITAIN'S FOREMOST DISTRIBUTORS

BIRMINGHAM · LONDON · MANCHESTER · LEEDS · NEWCASTLE-ON-TYNE · GLASGOW

CONTENTS

	Page
The Blue Pages	91
Possible New Methods of Rocket Propulsion	95
Liquid Thermosetting-Resin Insulation for Cable Installation and Maintenance	96
Ferritic-Austenitic Weld Joints in Thermal Power Stations	99
A Qualitative Separation of Wear Factors	102
New Oxidizing Method, using Borax, for Revealing Austenitic Grains	106
Abrasive-Erosion Phenomena in Hydraulic Turbines	107
Heat Transmission through Fins and Finned Cylinders	111
British Industrial Developments	115
Additional Abstracts	119
New Materials, Processes, and Equipment	122
News of the Month	126
New Technical Books	132
Latest Industrial Literature	A89

The ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XIX NO. 3 MARCH, 1958

EDITORIAL AND ADVERTISING OFFICES :

GREAT BRITAIN
120 Wigmore Street, London, W.1
Telephone : WELbeck 9357 & 6263

U.S.A.
366 Madison Avenue, New York 17, N.Y.
Telephone : MUrray Hill 2-8865

FRANCE
102 Rue Amelot, Paris (XI^e)
Telephone : VOL. 29-19

ITALY
Via Gran Sasso N.28, Milan
Telephone : 208.741

Annual Subscription Rates :
£2 2s. 0d. in the Sterling area, $7.50 in the Dollar area

Printed in Gt. Britain by THE ALCUIN PRESS, Welwyn Garden City, Hertfordshire, and published monthly by the proprietors, ENGINEERS' DIGEST LTD., 120 Wigmore Street, London, W.1.

PITMAN *TECHNICAL BOOKS*

THE STRUCTURAL ENGINEER'S DATA BOOK
By Derek A. Creswell, A.M.I.Struct.E., etc., and John H. G. King, A.M.I.C.E., etc. An indispensable handbook for all those connected with structural design. Specially devised for easy and quick reference, it is packed with up-to-date facts and figures that are constantly needed in the course of a day's work. 35/- net.

ELECTRICAL TECHNOLOGY (M.K.S. UNITS)
By H. Cotton, M.B.E., D.Sc., M.I.E.E. 7th Edition. A new and completely revised edition of Professor Cotton's famous work. In this edition the M.K.S. system of units has been adopted but the previous edition will still be available for those who do not want to use the M.K.S. system. An invaluable work for the electrical engineering degree student. Pitman's "Engineering Degree" Series. 50/- net.

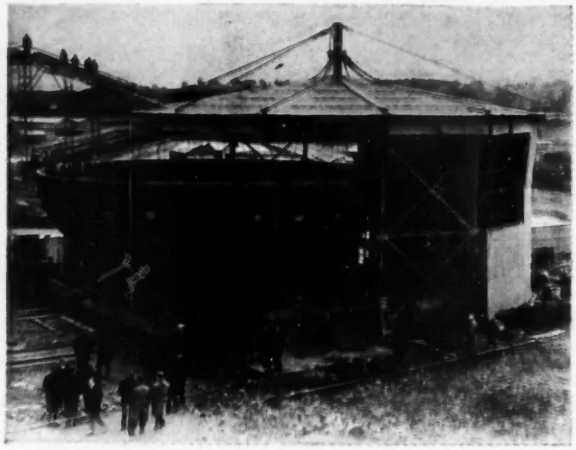
THE LAW RELATING TO BUILDING AND ENGINEERING CONTRACTS
By the late W. T. Creswell, K.C. Sixth Edition by D. R. Perrey, B.A.(Hons.) (Oxon.), Solicitor. A completely revised and up-to-date edition of this well-known book. It incorporates the 1939 (revised 1956) R.I.B.A. Standard Form of Building Contract. 30/- net.

FLUID PRESSURE MECHANISMS
By H. G. Conway, M.A., etc. 2nd Edition. This book deals with hydraulic and pneumatic machinery. It is not concerned with detailed design or constructional features, but with the essential principle of the various devices, how they work and how they differ fron each other. 32/6 net.

FACTORY LAY-OUT, PLANNING AND PROGRESS
By W. J. Hiscox, Edited by James Stirling. 4th Edition. The ideas given in this book are based on a very long practical experience of factory organisation and administration, and may be applied to any factory engaged upon any class of industry and worked in conjunction with any existing system. 12/6 net.

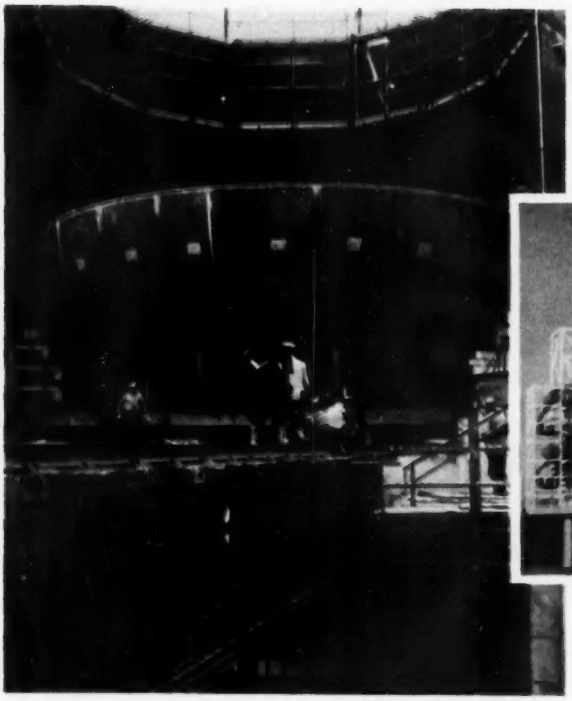
INDUSTRIAL ELECTRONICS
Elementary Principles and Applications
By Andrew W. Kramer. This book is primarily for those who have a good knowledge of general physics and engineering but who have had very little training or experience in electronics. It explains, step by step, in simple concise language and without the use of mathematics, what electron tubes are, how they work, how they evolved and how they can be used. 36/- net.

PARKER STREET · KINGSWAY · LONDON . W.C.2



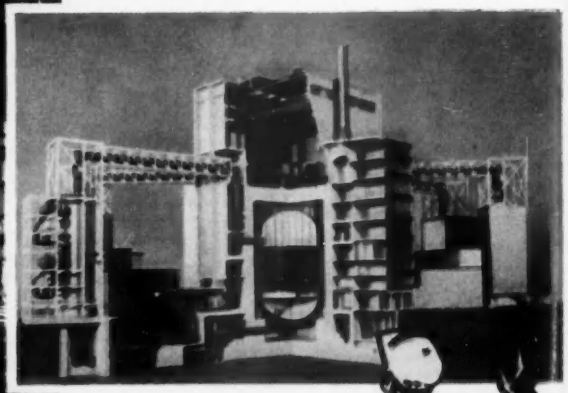
Above : While the foundations for the first of the station's two reactor vessels were being constructed, John Thompson teams of welders worked upon the lower bowl of the first reactor vessel on a temporary construction site, situated 180 yards from the final foundations. The three inch thick steel plates were pressed, prepared for welding and trial assembled at John Thompson's Wolverhampton works before transportation to site, where they were welded to class I pressure vessel standards.

And below : On Sunday, 20th October, the 180 tons bowl was moved on its railed bogie from the shelter of the temporary construction site to its permanent foundations



Buttercups at Berkeley...

John Thompson's construction men—familiar in their yellow helmets on power station and industrial sites throughout Britain—are now at work on the Central Electricity Authority's first commercial nuclear power station being built by the A.E.I.-John Thompson Nuclear Energy Company at Berkeley, Gloucestershire. Crisply, the construction programme proceeds to a minutely planned schedule. The 1,000-ton reactor vessel for Number 1 reactor is growing simultaneously with the reactor building. The " Buttercups " are speedily getting on with this job in which they are building the reactor vessels, the thermal shielding, the sixteen large heat exchange towers, gas ducting and nuclear fuel loading machines.



JOHN THOMPSON GROUP

JOHN THOMPSON LIMITED

JOHN THOMPSON LIMITED · WOLVERHAMPTON · ENGLAND

THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *PURIFICATION BY FRACTIONAL MELTING*

Fractional melting is a purification process which has recently been developed for substances that are difficult to purify under standard conditions. In general, fractional melting is a single-stage operation consisting of slow equilibrium-melting of a crystalline mass formed by slow equilibrium-freezing. The liquid sample is first placed in an ampoule and distilled into a fractional melting tube, where it is cooled to a temperature just below the freezing point. Beginning at the bottom, crystals grow slowly from this slightly supercooled liquid and, during this gradual crystallization, the crystals formed reject the impurity until solidification is almost complete. Consequently, the bulk of the contaminant is included in the crystalline network at the top of the sample. For this same reason the core of the crystal is uncontaminated, while impurities are found in the crystal periphery. When crystallization is nearly complete, the tube is inverted and heat is applied at the bottom, causing the crystals with the highest impurity content, which are then at the lower end, to melt first. As other crystals gradually liquefy and flow downwards through the crystalline network, liquid from the previously melted crystals bathes each succeeding crystal surface. Since fractions of the liquid are periodically drawn off from the bottom, the less pure material is progressively displaced by liquid of higher purity. Thus, the final fraction is extremely pure. For a maximum pure yield, it is important that the process of crystallization be extremely gradual, as this enables the crystal to form without the inclusion of surrounding impurities. Slow crystallization also produces larger crystals, which have a smaller ratio of surface area to mass, so that the total amount of absorbed impurity on the crystalline faces is reduced.

● *IMPROVED METHOD OF PRODUCTION OF PIG IRON AND STEEL*

Pig iron containing as much as 0·5% phosphorus can be converted by the surface-blowing of the molten pig iron with oxygen, provided that the iron is treated in relatively small quantities, i.e., in heats not exceeding one ton. With such small heats it is relatively easy to reduce the phosphorus content to 0·04%, without decreasing the carbon content below 1%, by maintaining a relatively low rate of oxygen supply and by adding basic slag-forming materials in accordance with general practice. However, one major difficulty in carrying out the small batch process is that it requires very accurate temperature control, as a few degrees variation in temperature at the end of the blowing period exert a considerable influence on the phosphorus content. In a recent patent specification it is pointed out that prior methods of oxygen-blast refinement of irons with high phosphorus contents are not practical for the refinement of pig iron in large quantities, i.e., in heats of 25 to 30 tons, the reason being that the oxygen supply would have to be so great as to render its use exorbitantly expensive. The invention envisages a new method of making steel or technically pure iron from pig iron with more than 0·2% phosphorus. Slag-forming materials are added to a bath of molten pig iron before and during the blowing of commercially pure oxygen against the surface of the bath, the rate of blowing being so adjusted that the phosphorus content is maintained below the carbon content of the bath. Oxygen blowing is initiated at a high rate and then decreased in order to decrease the rate of decarburization, while maintaining a high rate of dephosphorization. The rate of blowing is then again increased after the phosphorus content of the bath is reduced, so as to provide further decarburization and to purify the bath. Conventional equipment can be used, e.g., a crucible or converter-shaped vessel having a basic lining of the type ordinarily used for the treatment of pig irons of high phosphorus content.

● *SINTERED-ALUMINA SPRINGS*

By machining a series of rectangular helical grooves in a cylinder of fired alumina frit a synthetic sapphire spring is produced which exhibits good elastic properties at elevated temperatures up to 1800°F. It is reported that this method of producing a helical spring has been employed in the case of spring diameters from about 1 to 4½ in. with square " wire " sections from $\frac{1}{16}$ to $\frac{1}{4}$ in. The hardness of vitreous bonded alumina has an exceptionally high value, exceeding No. 9 on the Mohs scale, i.e., nearly that of diamond. Compression strength is also high, being from 280,000 to 400,000 psi, but tensile strength is low, ranging from 18,500 to 28,500 psi, thus limiting the working stresses for which a helical spring of this material can be designed.

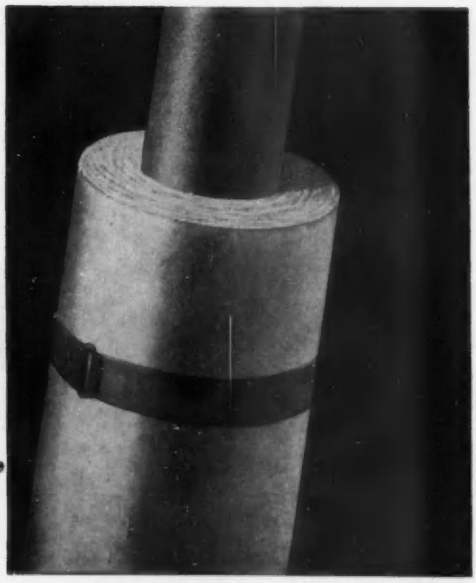
"I WAS A WASTER!"

—STEAM PIPE CONFESSES

"I am a four-inch bore pipe. I work in a factory. It is my job to carry steam at 450°F. from generator to the plant. But I was a waster, a fuel waster, a *very* fuellish waster indeed!

I used to work naked as the day I was drawn. Of course I wasted heat—and therefore fuel—but who cared? Then one day, a bright spark from Fibreglass told the Manager that I was wasting nearly one ton of coal a year through each foot of my length.

I felt naked—and ashamed. Quickly they had me wrapped in a Fibreglass rigid section 1¾" thick. Now, this is saving 18½ cwts. of each ton I used to waste. My conscience is clear; but if pride is a sin, I'd better look out. Because I *am* proud of my slim figure, my neat nesting and my light-weight on hangers."



FIBREGLASS
TRADE MARK

"RIGID SECTIONS WERE MY SALVATION!"

—STEAM PIPE TESTIFIES

For the whole story, please write to:

FIBREGLASS LIMITED, ST. HELENS, LANCASHIRE · ST. HELENS 4224

The material has good resistance to thermal shock, and its softening temperature is above 3100°F, while its electrical resistivity is high and its thermal conductivity is as low as 0·02 BTU/sq ft °F hr ft. These properties may make high-alumina springs valuable in certain components such as filament supports in thermionic tubes and in high-temperature relays. It is reported that tests have failed to establish a consistent design value for an elastic modulus, but the modulus is little affected by temperature. Tests between 68 and 1200°F, on $1\frac{3}{16}$-in. diameter springs show a constant spring rate of 0·91 lb/in. for a 30-coil spring of $\frac{1}{8}$-in. square ceramic-wire size. No precise spring rates have been determined above 1200°F, although experimental springs are operating at temperatures up to 2000°F.

● *METHOD OF CLADDING METALS*

A recent patent specification describes a new method of cladding a steel base piece with a steel-alloy piece. The two pieces are first tack-welded together to hold them in alignment, and are then moved on a conveyor through a furnace having an inert atmosphere, in which they are raised to approximately 2200°F. The hot pieces are then passed through an oxygen-free zone to a press, in which they are welded together throughout their contacting areas by a pressing process, which may be combined with a shaping process. Initial preparation of the contacting surfaces comprises providing them with a nickel paint, which consists of powdered nickel mixed with a suitable vehicle. The purpose of applying this paint is to protect the surfaces against any oxidizing effect and to improve the bonding qualities of the metals. In a modification of the process, the cladding metal is provided with a nickel layer by an electroplating process. The furnace is preferably heated by means of electrical heating elements and its outlet is connected with a downwardly sloping sealed chute which terminates at its lower end in the press, which can be of a conventional hydraulic type.

● *CHROMIUM DIFFUSION COATING PROCESSES FOR MOLYBDENUM AND COLUMBIUM*

Chromium diffusion coating or chromizing has long been known as a method of producing corrosion-resistant surfaces on ferrous parts. In this process, which is carried out at elevated temperatures ranging from 800 to 1000°C, chromium diffuses into the surface exposed to the chromizing agent, which may be in the vapour or the liquid phase. It is reported that new chromizing processes for non-ferrous metals have recently been developed which may considerably increase their usefulness. The claim is made that it is now possible to apply chromizing to molybdenum, columbium, nickel, and cobalt alloys. Particular importance would appear to attach to the possibility of chromizing molybdenum, as it has hitherto been difficult to take advantage of its outstanding high-temperature strength, because at high temperatures it forms a volatile oxide which leads to rapid erosion and eventual deterioration. Tests are reported to have shown that chromized molybdenum surfaces give better results than previously used ceramic or electroplated coatings. Chromized molybdenum is considered ideal for such applications as gas-turbine blades, ram-jet flame holders, turbine wheels, gas-generator assemblies, thermocouple protection tubes, nuclear-reactor rods, heat-exchanger tubes, missile combustion chambers, and many other high-temperature applications. Similar prognostications are made for the employment of chromized columbium. In fact, it is stated that chromized columbium should actually be more suitable than chromized molybdenum for certain high-temperature applications because, unlike molybdenum, columbium does not form a volatile oxide and can therefore be considered safer in critical applications. By applying the chromizing process to nickel and cobalt alloys, surfaces are produced which are capable of withstanding prolonged exposure to gases at 1800 to 2000°F, even in the presence of lead bromide, lead sulphide, sulphur dioxide, and other corrosives.

● *REDUCTION OF METALLIC OXIDES BY HIGH-PRESSURE HYDROGEN*

Difficulties exist in the production of metals from oxides which cannot readily be reduced, such as those of aluminium, germanium, titanium, zirconium, vanadium, tantalum, and chromium. These difficulties reside in the fact that it is very difficult to remove the last traces of oxygen, as well as of other impurities, such as nitrogen, present in the initial material or entering the reduced material during the reduction process. This difficulty also exists in the case of boron oxide and silicon oxide. A recent patent, however, claims that it is possible to reduce by means of hydrogen the oxides of metals which are difficult to reduce and to eliminate substantially all impurities, such as nitrogen, provided that the process is carried out at a pressure of at least 100 atm and at a temperature greater than 400°C. It is stated that studies on the effect of hydrogen applied under pressure have indicated that above 100 atm there occurs a widening of the lattice spacing of the metal structure, with a resulting steep rise in the ability of the hydrogen molecules to penetrate into the crystal lattices, and that this effect increases with the pressure. Consequently, effects are produced by the use of hydrogen at a pressure higher than 100 atm which cannot be obtained with pressures below this lower limit.

Service is a Tradition . . . .

We have always regarded the provision of a complete service, from design to finishing, as a major necessity between the conception of a product and its delivery to a market. That service, in the supply of zinc and aluminium die castings, is now traditional with us. Add to it our years of experience and we can present a very good reason why we are the largest pressure die casting organisation in the country, serving the needs of over 700 customers in 30 industries.

THE WOLVERHAMPTON DIE CASTING COMPANY LIMITED

GRAISELEY HILL WORKS · WOLVERHAMPTON · TELEPHONE 23831/6

Moreover, it has been found that the effect of hydrogen regarding the elimination of undesirable impurities can be enhanced if the high-pressure hydrogen is circulated and the impurities are continuously removed from the reaction chamber by cooling and purifying apparatus located outside the chamber. This apparatus may contain chemically active substances to bind oxygen, nitrogen, or other impurities, and may be cooled by liquid air or by a separate refrigerating unit.

● *COPPER-BASE BRAZING ALLOY*

A new brazing alloy has been evolved for use in brazing mild, low-alloy or stainless steels which are to be employed in the high-temperature zones frequently prevailing in heat exchangers receiving hot exhaust gases from gas turbines or other similar devices. The metallic components comprising a heat exchanger in gas-turbine service are continuously exposed to temperatures ranging from 900 to 1200°F and, to be satisfactory, joints bonding together such component parts must be capable of withstanding these temperatures for long uninterrupted periods at relatively high pressures, ranging from 60 to 100 psi. With these extremes of temperature and pressure, it is imperative that the material used as a bonding agent at the various joints should have sufficient strength and resistance to creep, to ensure that the tendency towards creep and ultimate failure will be reduced to a minimum. The most common brazing material with a reasonably high melting temperature is copper, which may be used at various temperatures ranging up to 900°F, though certain alloys containing various proportions of chromium and nickel have been developed with superior strength characteristics at temperatures ranging up to 2000°F. However, these alloys are extremely hard and present difficulties and problems in adapting them to the brazing operation. The new brazing alloy, which is stated to be malleable to the extent that it may be rolled in various forms to facilitate handling during brazing, contains from 85 to 95% copper, with from 3·5 to 10·5% nickel, from 0·825 to 2·44% chromium, from 0·175 to 0·56% boron, and small amounts of iron, carbon, and silicon not exceeding a combined total of 1·5%.

● *SENSITIVE METHOD OF DETECTING HALOGENS IN WATER*

For certain purposes, it is necessary to detect very low concentrations of halogens in water. For instance, in high-pressure steam generators it is essential that the oxygen content of the feedwater should be kept to a very low value, preferably as low as one part in 1×10^8 parts. Methods have been developed for detecting very small proportions of oxygen, involving the replacement of the dissolved oxygen by an equivalent amount of iodine, so that successful determination of oxygen content depends on an accurate estimation of the iodine content in the water. These methods, however, have certain inherent disadvantages. Thus, for instance, the method using starch is unreliable when the concentration is less than one part in 3×10^6 parts, while the more sensitive method of electrical detection is affected by the presence of other impurities in the water and is unreliable with concentrations of less than about 1 part in $1{\cdot}5 \times 10^7$ parts. According to a recent patent specification, these disadvantages have been overcome by a new, extremely sensitive method which is capable of giving satisfactory results with concentrations of about 1 part of iodine or other halogens in 8×10^8 parts of water. This method uses two electrodes connected together outside the water through a resistor of high ohmic value, i.e., between 0·1 and 500 megohms, the electrodes being of two different metals, e.g., tungsten and platinum, which cause an increased electric current to flow through the resistor when a halogen is present in the water, as compared with the current flowing when no halogen is present. The current through the resistor is measured by ascertaining the voltage drop across it. This voltage drop is proportional to the current through the resistor, and it is this current, rather then the difference in potential between the two electrodes, which is significant. The current flowing in the circuit shows a marked change when the last traces of halogens are removed, and reasonable quantities of other impurities in the water do not, as in other electrical methods of measurement, obscure the response of the system to changes in the concentration of halogens.

● *AUTOMATIC EQUIPMENT FOR CALIBRATING INTERNAL STRAIN-GAUGE BALANCES*

A feature of new automatic apparatus for the calibration of internal strain-gauge balances, which are used to monitor the performance of model aircraft, missiles, and structural parts in wind-tunnel tests, is the use of an accurate hydraulic positioning system with air-actuated transducers for sensing. In operation, this multiple-force equipment applies known forces to the balance being calibrated and permits the deflections shown by the internal strain-gauges in the balance itself to be related directly to the appropriate load. Static balancing is accomplished through seven flexure-ended struts which can introduce six force components to the balance through six lever systems. Two struts are used to apply rolling moment. Six horizontal loading struts are connected by bellcranks to load-beams which in turn support the load pans. The lever systems for the three forces operate

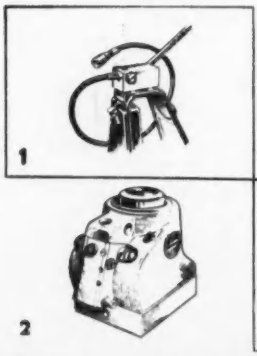
Hydra-pak

THE NEW

Hydraulic HAND PUMP

by

TANGYE



1 *The Hydra-pak on a tubular stand with oil cistern and pressure gauge.*

2 *This pump is incorporated in Tangye "Hydralite" 100 tons capacity jack.*

3 *The pump can be supplied mounted on a reservoir of 1 or 2 gals. capacity.*

This pump is a small, compact job, and will, with slight adjustments, cover a range of pressures up to 10,000 lbs. p.s.i.

It has two speeds, giving high or low pressure, and these are selected by a push-button control. Oil or water may be used.

We shall be pleased to furnish you with complete details.

Send for literature

TANGYES LIMITED

CORNWALL WORKS

SMETHWICK · BIRMINGHAM

AD. No. 48

on a 100:1 ratio and the three moments on a 1000:1 ratio. Calibration loads consist of accurate weights stacked on the load pans, and the load beams are counterweighted, so that a total weight, equal to the full-load range of the particular component, must be on the load pan when no load is applied to the balance. When any single load or combination of loads is applied to the balance being calibrated, it will deflect slightly, causing a slight angular displacement of the loading struts. To eliminate this condition, which can cause appreciable interaction forces, affecting the loads being measured in the balance members, a repositioning system is required, so as to restore the balance to the original position held without load. Balance-repositioning power is provided by a set of six hydraulic cylinders, each with an open-centre type of servo-control valve integral with the cylinder body. The control-valve spools are actuated electrically by signals transmitted from small pressure transducers which detect pressure changes in each of six air jets impinging on flat surfaces on the loading block, the centreline of each jet coinciding with that of its respective repositioning strut. As a load is applied, the loading block and the balance shift, causing one or more air gaps to be either opened or closed, depending on the direction of loading. The change in air-gap spacing is reflected as a change in pressure, which acts on a diaphragm, producing a small signal, which is subsequently amplified, on a strain-gauge, actuating the control-valve spool. This repositioning action can be effected with an error of $\pm 0{\cdot}0002$ in. for small loads and up to $\pm 0{\cdot}0005$ in. for larger loads.

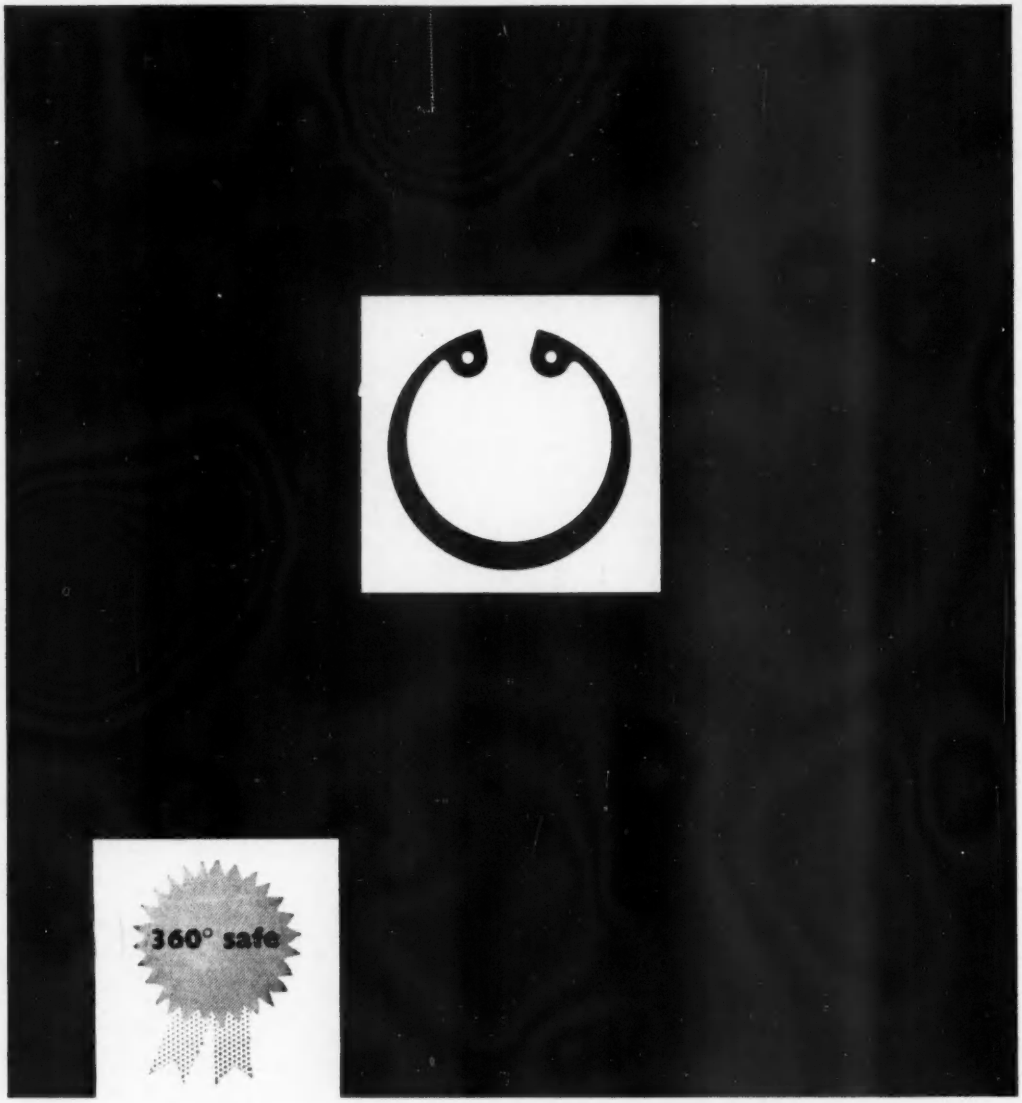
● *SIMPLE TECHNIQUE FOR DETECTING METAL FATIGUE*

An interesting surface phenomenon recently observed during the occurrence of metal fatigue may provide a useful technique for studying the effect of surface reactions on metal fatigue and for detecting the onset of fatigue cracks. Fatigue in metals subjected to repeated or fluctuating loads initiates as a tiny crack which gradually progresses through the metal undergoing stress. In the case of aluminium, it has been observed, using a time-lapse motion-picture technique, that materials are extruded in surprisingly large amounts, bearing in mind the size of the cracks. In an attempt to isolate some of this material, a piece of transparent pressure-sensitive tape was applied to the surface of a torsion fatigue specimen, in which fatigue cracks had already been induced by several thousand cycles of reversed stress. It was found that, when the specimen was stressed for an additional thousand cycles, small bubbles formed under the tape and further investigation revealed that these bubbles were produced as soon as detectable cracks were present. The significant feature of these bubbles is that, even when the actual cracks are so small that they can be observed only with a microscope, the bubbles are large enough to be detected with the naked eye. It therefore appears that this technique may be used to detect the onset of fatigue cracking, though it has now been established that the bubbles are produced with some metals and not with others. Thus, a strong tendency to form bubbles was noted in the case of stressed specimens of aluminium alloys, a moderate tendency in the case of cold-rolled mild steel, and a very slight tendency in the case of stainless steel. Apparently, bubbles do not form at all with brass or zinc.

● *MEASUREMENT OF GAS TEMPERATURES BY DIFFERENTIAL PRESSURE*

A recent patent describes a novel method of measurement of the temperature of high-temperature gases. Existing methods are stated to be unsatisfactory for a number of reasons, i.e., (1) the equipment has a comparatively high thermal inertia, so that indications deviate substantially from the actual gas temperature, particularly if sudden temperature changes occur ; (2) indications are influenced by the heat radiated from the walls of the cavity containing the gas and, if special screening is provided, the thermal inertia is still further increased ; (3) the calibration of such apparatus requires special equipment and cannot be carried out on site ; and (4) in view of its high inertia the equipment is not well suited for automatic control. The apparatus proposed comprises a tube which is connected at one end to the suction side of a pump and has at its other end an orifice with a differential pressure gauge. The tube is connected to another tube which is jacketed and is cooled in such a way that the gas, which is drawn into the tube by means of an aspiration tube connected to it, acquires a constant temperature. The aspiration tube also contains an orifice with a differential pressure gauge connected to it. For measurement of temperature with this apparatus, ambient air is first caused to flow through the apparatus, and the indication at the gauge of the aspiration tube is noted. The gas to be measured is then made to flow through the apparatus, and the suction of the pump is so adjusted that the gauge indicates the same pressure as before. The pressure indication at the gauge between the pump and the jacketed tube will then be a measure of the temperature of the gas.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.



SEEGER CIRCLIPS *were designed and first produced in this country twenty-seven years ago: throughout these years they have maintained a firm grip on the engineers' confidence*

Automotive Engineering Limited

One of the Sheepbridge Engineering Group
The Green, Twickenham, Middlesex
Telephone: POPesgrove 2206/9 Telegrams: MOTIF, Twickenham

THE ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS
VOL. XIX No. 3 MARCH, 1958

Possible New Methods of Rocket Propulsion

By B. D. Ross. (From *Machine Design, U.S.A.*, Vol. 30, No. 1, January 9, 1958, pp. 28–31, 10 illustrations.)

NEARLY all types of rocket motors are heat engines which convert fuel energy into heat and heat into kinetic energy. The quantity of heat produced is the difference between the heat of formation of the propellants and the heat of formation of the reaction products. Also, conversion of heat to kinetic energy becomes more efficient with a lighter molecular weight of the fuel products. The three requirements of high positive heats of formation for the propellants, high negative heats of formation for their products, and low molecular weight of the products must be combined as efficiently as possible, if the result is to be a good chemical propellant.

The fuel and oxidizer combination most commonly used to-day is a modified jet fuel and liquid oxygen, though a combination of aircraft kerosene and red fuming nitric acid is also in wide use. Boron fuels have been developed and are scheduled for limited production, while the use of fluorine, hydrogen, and other chemicals for propellant combinations are being investigated in the laboratory. Among the chief problems in connection with these fuels are their storage and the handling of inherently unstable elements at extremely low temperatures.

In the " Vanguard " rocket, the first stage burns jet fuel and liquid oxygen, the second stage aircraft kerosene and nitric acid, and the third stage a solid fuel. Of the total weight of the rocket assembly, almost 90% comprises the propellants.

In judging any fuel, the first characteristic to be considered is its specific impulse $I_s = F/W$, where F is the thrust produced [lb] and W is the fuel consumption [lb/sec]. Specific impulse is a function not only of the propellant, but also of engine design and, to compute even the theoretical specific impulse, the engine parameters must be specified. In a chemical system the theoretical specific impulse may be as low as 150 sec, while in the free-radicals systems, described below, it may be as high as 1280 sec. It is not surprising, therefore, that considerable research is being directed towards finding new forms of rocket propulsion, possibly involving the use of completely unusual forms of power, including fission, fusion, or " superatomic " forms of nuclear energy, solar heating, ion propulsion, and free radicals.

Fission and Fusion

Nuclear-reactor energy, obtained by fission, offers a potential improvement in specific impulse over chemical propellants of at least 50%. In the fission process, the nuclei of very heavy atoms, such as those of uranium 235 or plutonium 239, are split by the addition of a neutron into two smaller fragments of roughly comparable size, plus several neutrons. The heat energy released by nuclear fission in a reactor can therefore be used to vaporize a suitable working fluid, e.g., ammonia, helium, or hydrogen, propulsion being achieved in the ordinary way by reaction.

In the fusion process, the nuclei of two light atoms, such as isotopes of hydrogen, are fused together to produce a single heavier nucleus, plus either a proton or a neutron. As in the case of the fission process, the difference in mass between the two fusing nuclei and the single nucleus produced appears as kinetic energy, developing large quantities of heat which, as before, can, in theory at least, be used to vaporize a suitable working fluid.

Superatomic Energy

An interesting proposal by Dr. Robert L. Carroll, the U.S. Navy physicist, is to make atoms extremely cold, instead of hot. He suggests that, as an atom becomes colder and less active, its electrons gravitate towards the nucleus and, at the same time, are forced to move more and more quickly. Consequently, if the atom becomes cold enough, the electrons would plunge into the nucleus, thus releasing its total energy.

Although the theory behind this proposal challenges the concept that temperatures cannot be reduced below the accepted absolute zero and that no speed can exceed that of light, it should be noted that the U.S. Air Force has agreed to explore the possibilities of his proposal and to invite a group of leading scientists to discuss his theory at a special conference.

Ion Propulsion

Ion-propulsion development, now being studied in various laboratories, may lead to its application in flight beyond the atmosphere. In this method of propulsion, thrust is developed when an electrical or magnetic field is used to accelerate a stream of ions. The resulting reaction may provide a low-level thrust for the gradual acceleration and control of the orbit of a satellite vehicle.

For producing copious streams of ions, possible methods include ionization by electric-arc heating (the so-called " plasma jet "), by collision, by electromagnetic radiation, by nuclear reaction, by chemical reaction, by shock tubes, and by surface films in an intense electrical field.

Solar Power

Rockets powered by solar energy are a promise of the future. A " sunbeam-propulsion " system, long proposed by Ehricke, is aimed at eliminating the need for a source of energy when a vehicle is in space, though the supply of hydrogen used as the working fluid would have to be carried from the point of take-off.

Basically, his proposal involves a hydrogen-operated vehicle of 16,000 lb gross weight, including 11,000 lb of liquid hydrogen and a gondola with two crew members. Radiant energy is collected from the sun by two thin-walled plastic spheres; one half of each is sprayed with a thin metallic film for reflection, while the other half is highly transparent. Located in the centre between the two collectors is the gondola, the hydrogen tank, and the

(Concluded on page 114)

U.S.A.

Liquid Thermosetting-Resin Insulation for Cable Installation and Maintenance

By E. W. Bollmeier. (From *Power Apparatus and Systems* (*A.I.E.E.*), No. 33, December 1957, pp. 874–882, 15 illustrations.)

The factors of cost reduction, reliability, and reduction of skill have been sufficient to imply the usefulness of the resin-insulation process in a wide field of applications for installation and maintenance splicing of cable. Efforts towards improved quality, with even lower cost and reduced maintenance skill, have been successful in many applications of thermosetting-resin splice insulation to power and communications use, and versatility and adaptability in a variety of cable constructions have been achieved.

In brief, the resin-splice insulation concept has two requirements, i.e., (1) a low-viscosity liquid polymer capable of reacting to form a solid, insulating mass, and (2) a means of distributing and containing the liquid in the form and thickness desired around the region to be insulated, until reaction to the solid state is complete.

Many detail requirements must be met to satisfy the end purposes of field-applied insulation, but basically the concept is one of simplicity. As distinct from present conventional practices, laborious incremental placement of insulation is not required, neither must the outer enclosure be of the permanence necessary for oil-insulated members. The liquid thermosetting insulation may be applied in one continuous volume by pouring or injecting the resin into a mould of temporary liquid tightness. Polymerization of the liquid to the solid state produces a solid insulation having mechanical strength and no further need for a liquid-tight enclosure.

Thermosetting Liquid Polymers

Thermosetting organic polymers of the epoxy, rubber-modified epoxy, polyester, polysulphide, and polyurethane structures are all used to-day in varying degrees for electrical insulation and encapsulation. As a group, these polymers can be formulated into pourable, reacting liquids which will cure to the solid state. Their solid properties and reaction speeds vary over wide ranges, depending on such factors as molecular weight, cross-linking, chain structure, curing system, and degree of cross-breeding.

An accurate numerical-value comparison of all mutations of these polymers requires painstaking analysis to reach accurate conclusions as to the usefulness of each for field-applied insulation uses. In any qualitative comparison, the more important electrical properties and those reaction and mechanical properties demanded for field use must be given equal prominence, and it is essential to consider simultaneously all these properties when selecting a polymer for field use, because, as a group, they become what may be termed an " index of practicality ". For instance, glass might appear to be an excellent field-applied insulation if work ability and mechanical properties were disregarded.

Taking into account such properties as dielectric strength, dielectric constant, dissipation factor, ability to cure without external heat, mechanical-shock resistance, and thermal-shock resistance, polymers of the epoxy type and rubber-modified epoxy type may be said to have the highest index of practicality, followed by polymers of the polysulphide, polyester, and polyurethane types.

Epoxy resins are a class of polymer which cure through an oxygen bond without the formation of condensation products. Epoxy polymers exhibit a combination of high adhesion, minimum shrinkage, heat stability, and moisture resistance, exceeding that of any other class of resins known commercially at present.

The most common type of epoxy resin in commercial use to-day is of the bisphenol-A-epichlorhydrin reaction. Substitution of certain other materials for bisphenol-A yields epoxy resins having higher reactivity or differing physical cured properties, ranging from rubbery toughness to glass-like brittleness. Obviously, much can be done to formulate thermosetting-epoxy-resin systems which have widely different reaction and finished properties, but this paper is concerned with formulations of low viscosity and rapid reaction without external heat, as these formulations are most suited for use in the field.

The rubber-modified epoxy resins exhibit much of the high electrical properties exhibited by unmodified epoxy resins and excel in mechanical and reaction suitability for field application. It is because of this that the modified epoxy at present enjoys the widest use in the field.

Consideration of the overall properties of a representative rubber-modified epoxy resin reveals no single extraordinary property as an insulation. Rather, it is the overall combination of electrical, mechanical, and reaction properties which gives the resin practical usefulness as a field-applied insulation.

Design and Application of Resin Insulation

The largest requirement for field-applied insulation is for splicing and terminating cable, and three application processes in current use have reached greatest development in these fields, i.e., (1) the poured-resin insulating process, (2) the resin-pressure insulating process, and (3) the built-up cloth-resin insulating process.

Poured-Resin Insulating Process :—

Assuming the resin selected is adequate mechanically and electrically, proper design of the poured splice is dependent largely on the mould used to contain the resin during reaction. Single-use plastic moulds which are left in place have met with the greatest acceptance.

Liquid tightness of the mould is essential for reliable results with the poured-resin splicing process. Tongue-and-groove snap-tight joining of the mould halves is found to be most practical in assuring easy installation and reliability of tightness.

Adequate provision for air venting must be made, and this is accomplished basically in the pouring process by means of two pouring spouts in the mould design, one to accept resin and the other to discharge air. One type of snap-tight tongue-and-groove mould incorporates a special venting joint which passes air freely, but seals when wetted by resin. This feature permits free filling through both pouring spouts simultaneously, if required, since it is possible for air to escape through the seam at any point.

Dimensional stability of the mould during the reaction exotherm period is necessary to prevent shifting or sagging of the mould under the weight of the resin. The proper selection of mould material for high heat-distortion temperature can eliminate reliability problems due to mould distortion. Moulds formed by injection

moulding benefit from the wide range of materials adaptable to this manufacturing process.

Adequate dielectric section thickness and seal length to the cable sheath must be ensured, and are determined by the electrical and mechanical properties of the resin and connector design. Poured-type splices have been limited largely to date to use on non-shielded cable at voltages of 5 kV and lower. A minimum section thickness of $\frac{1}{4}$ in. provides an adequate safety factor in this service voltage range on cable rated at 80°C; smooth solder sleeve- or compression-type connectors are best suited for low-stress and minimum insulation requirements. Seal length has been studied experimentally, and it is concluded that a seal with a length of two to three times the diameter of the cable provides a high safety factor on all types of cable insulation and jacketing.

Resistance to weathering is important, and all organic materials are known to improve markedly in weather resistance, when pigmented so as to be opaque to ultraviolet radiation. Carbon-black pigmentation of the mould extends its weathering life to approximately that of the cable. Thus, the resin, even though weather-resistant, is essentially unaffected by the eroding effects of the elements during the life of overhead-cable insulation. Better selection of resin for optimum mechanical and electrical properties is made possible by the reduction in required weather resistance permitted by opaque weather-resistant moulds.

In the poured-resin insulating process, the means of handling and mixing resin has great practical importance, since a minimum of error is also essential here for splice reliability. A minimum of skill, time, and decision by the user is important for the achievement of overall minimum cost and error.

Resins may be packaged in several ways which keep the resin and its curing agent separated until required for use. Glass or metal containers may be used and the materials stirred together with a paddle. One method of packaging and mixing has been commercially developed which combines accurate proportioning of resin and curing agent and ease of mixing in a single flexible-film package.

This package consists of two compartments separated by a rupturable barrier, the resin and curing agent being packaged in the two compartments. The barrier may be ruptured by pulling the sides of the package, and the contents mixed together by kneading the package. Resin packaged and prepared for use in this manner leaves little possibility of unreliability, since proportioning and formulation cannot be accidentally affected by the user.

Resin-Pressure Insulating Process :—

Recognition of the availability limitations of moulds in the poured-resin process for non-standard or low-volume applications has led to the development of the resin-pressure insulating process, in which pressure is used to ensure complete resin saturation and elimination of voids in the region to be insulated.

The mould for the resin-pressure insulating process may be described as a framework made of a continuously adjustable spacer covered with a liquid-tight membrane. The spacer is composed of a continuous length of heavy caliper screenlike insulating material which is wrapped quickly on the region to be insulated, thus constructing a porous framework of any desired dimensions. The spacer screen found most practical to date is composed of 20-mil tensilized-polyethylene or vinyl-copolymer filament woven into a 12 × 12 mesh-screen tape. If this framework is then covered with a liquid-tight membrane of plastic tape, a mould of stable dimensions has been completed. Such a mould cannot be poured successfully, but it can be filled void-free by injection with resin under pressure.

Although splices completed in this way may superficially resemble taped splices, they require significantly less skill and labour. The pressure-splice mould utilizes the best attribute of a tape-like material, i.e., adjustability to " fit " objects of varied shape and size. However, the pressure splice eliminates the care and skill required with built-up tape insulation. Any thickness of spacer can be built up rapidly without regard for proper butting, lapping, or imperfect conformance. The pressure-splice framework merely determines the total thickness of insulation. It is united and washed free of air by a continuous one-piece matrix of insulating resin. The framework also serves to reinforce the resin, producing additional mechanical strength, impact resistance, and improvement of electrical properties.

The splice does not fill from the bottom up, but from the centre out, the resin forcing air ahead of it as though it were a piston. The point of injection may be located anywhere on the splice with equivalent results. The spatial attitude of the splice, horizontal or vertical, is also of little importance.

Indication of complete filling is provided in practice by piercing small holes through the tape membrane at all extremities of the insulated member. When resin is seen as a droplet at each of these holes, the framework is known to be filled and void-free. Excessive flushing with resin is unnecessary.

The same general requirements for practical packaging and mixing of resin apply to both the poured and pressure processes. Resin packaged in glass or metal containers can be paddle-mixed and poured into a piston-cylinder injection tool. On the other hand, the flexible-film package described previously is well adapted to the pressure process. In addition to providing protection from the disadvantages of open-container mixing, the flexible-film package of resin can be loaded directly into a tool which compresses the whole package. The resin can be thus forced from the tool under pressure, and the package serves as a collapsing liner, preventing the resin from contacting the tool and eliminating cleaning.

The versatility of the resin-pressure insulating process suggests many possible applications. Thus, practical field uses include splicing, terminating, bus insulation, sheath repair, oil blocks, sheath insulating joints, and general sealing against liquids or gases. For all these possibilities, the mechanical and electrical properties of the resin-saturated spacer equal or exceed unreinforced cured-resin properties. A primary advantage of the resin-pressure process is its ability to accomplish the above applications with the same basic materials, i.e., resin, spacer, and plastic-tape membrane.

Built-up Cloth-Resin Insulating Process :—

The built-up cloth-resin process, which may be compared with the glass-cloth and polyester-resin process currently used for the construction of small boats, involves wrapping with a fabric tape and painting with an activated resin to saturate the open weave and to bind the layers together. It yields an insulating fibre-resin section after cure which is mechanically strong, impact-resistant, and with good electrical properties, if proper care and skill have been exercised in application.

The fabric used for the build-up has been largely of a woven glass-fibre type. Studies of the effect of various

fibrous-material/resin combinations conducted by the author have shown that twisted fibre threads are exceedingly difficult to saturate, particularly when sized with the various oils and starches necessary for the weaving process. Study of the electrical properties with water immersion show that unsaturated fibrous threads definitely provide less resistance to moisture transmission than the basic epoxy resin used for saturation. Glass cloth, pyrolyzed to burn out sizing, is available. This fabric is superior, but is still difficult to saturate, compared with a non-woven bonded fibre fabric or plastic mono-filament fabric.

The fabric-resin built-up insulation process, like the resin-pressure process, should definitely be considered for many uses which demand that horizontal or vertical application be possible, in any diameter, length, or configuration. If a fabric woven of twisted-strand thread is used, applications as a primary insulation over 5 kV under wet conditions should be carefully considered.

As distinct from the poured-resin and resin-pressure processes, the built-up process is a " wet " method, i.e., the building of size and shape is effected with a fabric wetted with activated resin, whereas the size and shape of poured-resin and resin-pressure insulation are determined with dry materials and the resin is applied in a final operation.

Continuous handling of the resin from an open container during the wet build-up requires specific precautions, in order to avoid chemical irritation or allergic reaction to some of the formulations available commercially to-day. In general, the user should take all possible care to avoid personal contact with the resin. If personal contact does occur, the contacted area should be washed clean with soap and water as soon as possible. The irritating effects of epoxy and other resins vary with formulation, but all should be handled with care.

Service Ratings of Resin Insulation

The installed service rating of any field-applied material is dependent on engineering design, operating environment, and care during installation. This rather obvious statement is made as a reminder that both remarkable and doubtful laboratory-measured properties require field experience for final judgment.

Some conclusions can be reached from the measured properties of cured liquid thermosetting resins. Resins of inadequate mechanical or electrical properties become obvious with relatively little test work, but practical application work is necessary to assess the installed value of resins with optimum measured overall properties. For this reason, work conducted by the author has been mainly concerned with practical applications

As pointed out in the discussion of possible resin systems, electrical, mechanical, and reaction properties are assumed of equal importance in forming an index of practicality. The rubber-modified epoxy resin has been noted as having the best blend of properties for wide practical use at the current state of development.

The rubber-modified epoxy resins available commercially to-day do not possess characteristics permitting their unrestricted use. In service, the variety of possible environments requires consideration when stating overall ratings for the poured-resin and resin-pressure insulating processes. Assuming a cable insulation of thermoelastic synthetic oil-paper for the poured-resin process and synthetic thermoplastic oil-paper for the resin-pressure and built-up cloth-resin processes, Table I gives reasonable service ratings established by laboratory measurements and present field experience. In all three processes, the maximum temperature rating is 80°C.

The differences in recommended service ratings are due to the following four factors :—

(1) The poured-resin process is not readily suited to full-shielded splicing without provision of special preformed self-supporting shielding inserts.

(2) The resin-pressure process is adaptable to all shielding requirements, thus having broader application to shielded cable.

(3) The resin-pressure process exhibits higher electrical properties than the poured process, using the same resin.

(4) Cloth-resin built-up insulation is limited to less moisture resistance than the resin alone, if a fabric with a twisted-fibre thread is used.

Factor (3) is explained by the fact that the spacer-resin combination exhibits a layer-gradient behaviour. Although the resin-filled spacer is a continuous reinforced casting, the layer-applied spacer interrupts straight-line resin continuity in all directions. The voltage-stress distribution consequently adjusts itself to a compromise between a continuous-resin section and a layer section of resin-spacer-resin, etc. The higher properties demonstrated by a void-free layered insulation, compared with a solid section of the same insulation, are partially taken advantage of by the pressure process.

Table I : Service Ratings of Rubber-Modified Epoxy Insulation Processes

Process	Overhead Insulation [kV]	Direct Burial Underground or Water Immersion [kV]	Secondary Insulation or Terminations [kV]	
			Indoor	Outdoor
Poured-resin	7·5*	5	15*	7·5*
Resin-pressure	15†	15†	27†	7·5†
Built-up	15†	5†	27†	7·5†

* Stress cone termination of shielding over 5 kV.
† Stress cone terminated or continuous shielding.

The service-rating recommendations for all processes are to be upgraded by the use of resins and accessory materials now in evaluation. However, it is strongly recommended by the author that consideration of application for primary insulation be limited to 15 kV, until sufficient field experience has been accumulated and reported by those now using these insulation processes.

Conclusion

Since the greater proportion of cable installation and maintenance at voltages higher than 5 kV is performed by public utility companies, the final proof of resin insulation at high voltages must be furnished by their use. Resins may offer a general solution to field-applied insulation problems, but dependability and economics will be proved only by accumulated field experience.

The poured-resin, resin-pressure, and built-up cloth-resin insulating processes together provide a means of application to the majority of field problems. Considerable merit should be attached to the universal application of these processes to the variety of cable constructions now in use. Resin insulation provides a means of joining many different insulation types, thus alleviating the problem of stocking specific splicing materials for each type.

The resin-pressure and built-up insulation processes have the greatest versatility, but no attempt should be made to eliminate the poured splice for standard applications which can take advantage of the greater time and material saving available through standard mould designs. At the same time, resin cannot replace tape, when the use of tape is sufficient.

Ferritic-Austenitic Weld Joints in Thermal Power Stations

By F. ZIMMER. (From *Revue M.*, Vol. 3, No. 4, October 1957, pp. 162–174, 16 illustrations.)

THE problems associated with weld joints between ferritic and austenitic steels which are subject to high temperatures and especially to high-temperature cycling have been receiving much attention since 1947, when steam temperatures of 565°C and above were first used in commercial steam power stations. The temperature range of 560 to 580°C represents the upper limit for the use of ferritic steels, because of their decreasing mechanical strength and oxidation resistance ; at the same time, it also represents the lower limit for the economic use of austenitic materials, which at high temperatures possess more favourable mechanical and chemical properties than ferritic steels. As the economics of plant design require the selection of materials on the basis of minimum cost for any particular application, some sections of the steam plant will be made of austenitic and others of ferritic steels, and joints between these two materials become necessary. The ferritic steel most frequently used when dissimilar welds are required contains 2·25% Cr and 1% Mo ; on the other hand, the austenitic steel most frequently used for welding to ferritic steel contains 18% Cr and 8% Ni, and is stabilized with titanium or niobium.

A ferritic-austenitic weld joint in the superheater or a steam pipe of a high-temperature power-station boiler must stand up to a combination of several unfavourable factors, of which the principal are (a) severe and complex mechanical stresses due to internal pressure, different thermal expansion and conductivities of the two metals, and residual welding stresses ; (b) carbon migration from the ferritic to the austenitic steel, leading to an increase in the grain size in the decarburized zone, with consequent embrittlement ; and (c) stress corrosion in the decarburized zone of the ferritic steel.

To prevent these phenomena and particularly the effects of thermal and pressure cycling, specially alloyed and stabilized steels are being employed, and special joints have been developed between ferritic and austenitic parts. A survey is given in this paper of the principal types of ferritic-austenitic weld joints used at the present time, including an assessment of the extent to which they succeed in preventing the effects of the adverse factors mentioned above.

ELECTRICALLY HEATED JOINTS

To ensure that the joint remains at a high temperature both in operation and during shut-down periods, thereby eliminating thermal cycling, the weld joint can be provided with an appropriately dimensioned electrical resistance heating element. When the temperature of the joint falls by about 100°C, a thermocouple (Fig. 1) causes the heating element to be energized. This method is widely used in Great Britain for boiler tubes and steam pipes, in particular by Babcock & Wilcox. It is mainly applied to the "Kelcaloy" type joints originally developed in the United States, to which more detailed reference will be made. Electric heating of welded joints also appears to be practised in the U.S.A.

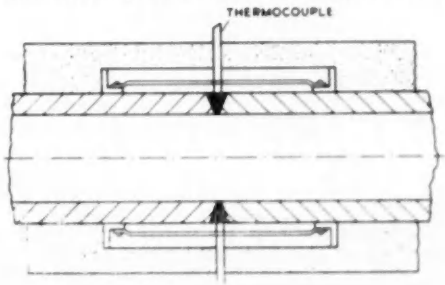


Fig. 1. **Electrically heated joint.**

JOINTS USING STABILIZED FERRITIC STEEL

Austenitic-ferritic joints using a ferritic steel stabilized with niobium or titanium, to prevent carbon migration, are shown in Fig. 2. In Fig. 2a, the weld metal is of the same composition as the ferritic base metal, except that it has been niobium- or titanium-stabilized. In Fig. 2b, the interface of the ferritic base metal is built up with stabilized ferritic weld metal, and the weld proper is then made with austenitic weld metal. In Fig. 2c, the austenitic and ferritic base metals are separated by a transition or intermediate joint of stabilized ferritic steel. These three types of joints are favoured by the Babcock & Wilcox Company in Great Britain.

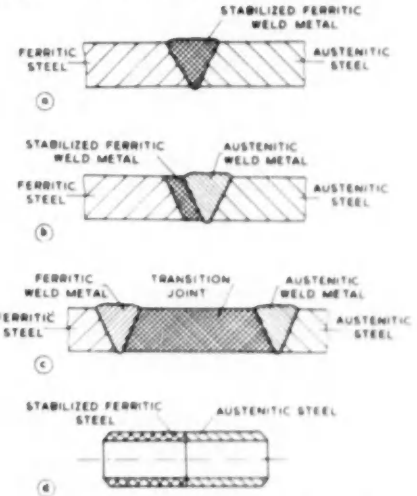


Fig. 2. **Various joints using stabilized ferritic steel.**

The type of transition joint shown in Fig. 2d is made by the Phoenix-Rheinrohr Company, of Western Germany, for use on superheaters. Here, the joint comprises a short length of stabilized ferritic tube, butt-welded to a short length of austenitic tube. After welding, the transition joint is carefully machined, both inside and out. The stabilized ferritic portion contains 2·25% Cr, 1% Mo, and 1% Nb, while the austenitic portion contains 16% Cr and 13% Ni. It is claimed that, contrary to some opinions, the hot strength of the ferritic steel used is not inferior to that of a similar steel without niobium stabilization, and that such a reduction in hot strength is produced only when the ferritic steel is stabilized with titanium, the action of which is more complex and less favourable than that of niobium.

These four joints have the advantage that they suppress the decarburization of the ferritic steel when it is

in contact with an austenitic steel. In consequence, the ferritic part is more resistant to pressure and thermal cycling, as well as to stress corrosion, than would otherwise be the case. These joints do not, of course, eliminate differential thermal expansion stresses ; on the other hand, if the amount of stabilizer (Ti or Nb) is excessive, carbon will migrate from the stabilized to the non-stabilized section of the ferritic part, resulting merely in shifting of the decarburized zone, and not in its elimination.

Ferritic-Austenitic Joints with a Protective Overlay

In the U.S.A., the Babcock & Wilcox Company have developed a technique which practically eliminates the risk of stress corrosion in the decarburized zone of the ferritic part, and which provides for the application of several passes of a special weld metal along and across the line of demarcation between the ferritic part and the austenitic weld metal of the joint (Fig. 3.).

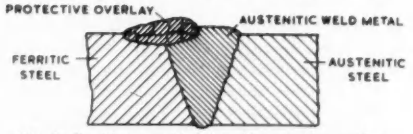


Fig. 3. Ferritic-austenitic joint with protective overlay.

The protective metal should have a thermal expansion intermediate between those of the ferritic and austenitic materials and should have a high oxidation resistance, so as to form an impenetrable oxygen barrier, the electrode composition which best meets these conditions being 80%Ni/20%Cr. This method is considered appropriate for the repair of joints showing signs of corrosion fatigue in the decarburized zone ; it does not, however, prevent or eliminate thermal expansion stresses or decarburization of the ferritic steel.

Joints with a Special Nickel-Chromium Weld Metal Containing Columbium and Tantalum

A special 50%Ni/10%Cr weld metal containing columbium and tantalum, developed in the U.S.A. by the Babcock & Wilcox Company, has two main advantages, i.e., (1) owing it to its high nickel content, its coefficient of thermal expansion is very close to that of ferritic steel, and (2) it prevents carbon migration.

As regards the interface between the weld metal and the austenitic steel, the severity of conditions is reduced ; in fact, both materials are austenitic and, although their coefficients of thermal expansion are different, their hot strength is high and of the same order, and both have a high oxidation resistance. Under these conditions, a joint between two austenitic materials can more easily cope with the effects of differential expansion stresses, and stress corrosion is unlikely to occur.

It appears that these electrodes are not at present on the market, as they are manufactured by Babcock & Wilcox exclusively for their own use. However, an electrode of somewhat similar properties, produced by the International Nickel Company under the designation " Inco Rod A ", is available commercially.

Transition Joints with Intermediate Coefficients of Expansion

Fig. 4a illustrates a joint incorporating a transition or intermediate joint whose coefficient of thermal expansion (16×10^{-6} per °C) lies between those of the ferritic and austenitic steels. Transition pieces or joints of this type halve the stresses caused by the different thermal expansion of the two metals. They are made, amongst other firms, by Sandvik, who use a high-nickel material containing 0·07% C, 3% Cr, 80% Ni, and 0·8% Nb.

Tests have shown that cyclic heating does not produce cracking and that, owing to the high nickel content of both this transition joint and the weld metal on the ferritic side, decarburization is on only a very small scale. The only weakness of the high nickel content is low resistance to attack by combustion gases containing sulphur or vanadium, and it is for this reason that an alloy containing less nickel is now being developed.

A transition joint marketed by Thos. Firth & John Brown, Ltd. of Sheffield, also has a coefficient of thermal expansion of 16×10^{-6} per °C, but its composition is significantly different from that of the Sandvik material, inasmuch as it has a considerably lower nickel content (30 to 40%) and a higher chromium content (10 to 15%). This alloy probably has a satisfactory corrosion resistance to sulphur-containing gases, but is less satisfactory with respect to decarburization.

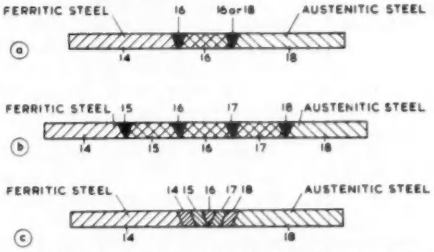


Fig. 4. Transition joints with intermediate coefficients of expansion.

In addition, Firth-Brown produce transition joints with other coefficients of expansion. Thus, in Fig. 4b is shown a welded joint comprising three transition joints with coefficients of expansion of 15, 16, and 17×10^{-6} per °C respectively, the weld metals between these pieces having coefficients of 15, 16, 17, and 18×10^{-6} per °C. Similarly, Fig. 4c shows a welded joint consisting of five layers deposited by five different electrodes with coefficients of expansion of 14, 15, 16, 17, and 18×10^{-6} per °C respectively. The chemical compositions of the individual transition pieces and weld metals are given in Table I.

Table I

Coefficient of Thermal Expansion [$\times 10^{-6}$ per °C]	Composition [%]				
	C	Cr	Ni	Co	Nb
14	0·14	10–15	30–40	10–20	1·3
15	0·14	10–15	30–40	5–10	1·3
16	0·14	10–15	30–40	—	1·3
17	0·14	10–15	20–25	—	1·3
18	0·14	10–15	14–18	—	1·3

The joints shown in Figs. 4b and 4c reduce by 75% the differential expansion stresses which would occur in a simple welded joint between ferritic and austenitic steels. Unfortunately, however, they have the drawback that the joint in Fig. 4b requires four welds with four different electrodes—a complicated and not very practical procedure—while the joint in Fig. 4c requires five different weld deposits from five different electrodes, so that its technical execution presents considerable difficulty.

" Kelcaloy " Transition Joints

The " Kelcaloy " transition joint, developed in the U.S.A. by the Kellogg Company, is shown in Fig. 5a and

comprises an internal forged ferritic tube, onto which is cast, in a special machine, an external tube of austenitic steel, the piece being annealed for 4 hr at a temperature of 850°C and subsequently machined to the final dimensions.

Although this method offers the advantage of producing a longitudinal joint which is less dangerous than one which might lead to a transverse rupture of the wall, it has the disadvantage of protecting neither against decarburization nor against differential expansion of the two steels ; it also renders the cast austenitic part liable to cracking during subsequent welding. Nevertheless, considerable numbers of joints of this type have been in use in the U.S.A. and Great Britain for 7 or 8 years and have given satisfactory service. However, in Great Britain at least, and probably also in America, Kelcaloy joints on steam pipes are always provided with electric heating.

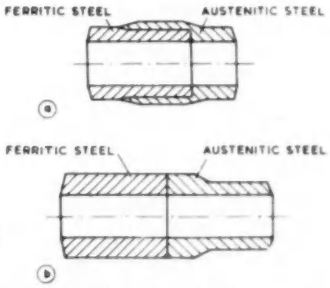


Fig. 5. "Kelcaloy" transition joints.

This joint is now being superseded by the joint shown in Fig. 5b, which consists of a short forged ferritic and a cast austenitic piece, the two being butt-welded. Tests carried out in Great Britain by the Central Electricity Authority and several manufacturers have been successful. It is recommended that electric heating be provided and that during shut-down of the turbine the temperature be maintained at between 425 and 455°C. The largest internal diameter at present being made is of the order of 200 mm.

British Babcock & Wilcox Transition Joint

A transition joint developed in England by Babcock & Wilcox basically comprises an inner austenitic tube cold-expanded into an outer ferritic tube, which is provided with grooves on its inner surface (Fig. 6).

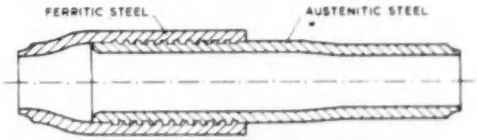


Fig. 6. Babcock & Wilcox transition joint.

As the austenitic tube has a higher coefficient of thermal expansion than the ferritic tube, it exerts a high pressure on the outer tube when hot, thereby enhancing the tightness of the joint.

Mannesmann Transition Joint

The Mannesmann "Schweissverbinder" transition joint consists of a ferritic outer element and an austenitic inner element, the interface between the two being of conical shape and provided with an electrolytically deposited layer of nickel, 30 to 60 microns in thickness. The interface can be smooth, as shown in Fig. 7, or alternatively it can be threaded, so as to increase resistance to pulling apart of the elements, which are forge-welded together at a high temperature, using pressures up to 60 kg/mm².

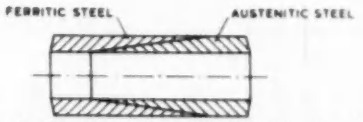


Fig. 7. Mannesmann "Schweissverbinder" transition joint.

Tests, including thermal-shock tests, have shown that the layer of nickel, while virtually preventing carbon migration entirely, does not affect the quality of the joint. These transition joints are made in various sizes, ranging from 14 to 130 mm i.d., and it is stated that the smaller and medium sizes have been in use for some time and have given satisfactory service.

Flanged Joints

A type of joint frequently used in Germany is the Mannesmann flanged joint shown in Fig. 8, which comprises two flanges, one of austenitic and the other of ferritic steel, fitted with elastic sealing elements, welded together to ensure tightness; in fact, this is the only ferritic-austenitic weld in the whole assembly.

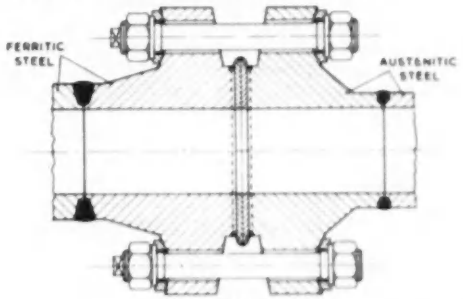


Fig. 8. Flanged joint.

As the transverse expansion of the austenitic flange is greater than that of the ferritic flange, the axis of the bolts joining the two flanges moves in relation to the axis of the tube, and, to avoid bending stresses, the bolts are swivel-mounted.

Joint used at Leverkusen Power Station

A joint which is used at the Leverkusen Power Station in Germany and which is reported to have given satisfactory service is shown in Fig. 9. This joint provides for mechanical interlocking of the ferritic and austenitic members, with two ferritic-austenitic seal-welds between them. The disposition of these welds is such that, in the event of their cracking, the mechanical strength of the joint is not affected.

It should be noted that, to eliminate the possibility of separation of the shoulders of the members, the joint

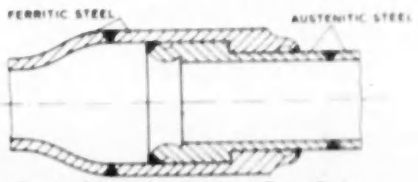


Fig. 9. Joint used at Leverkusen Power Station.

must be located in a position where the effect of steam pressure exceeds that of the differential thermal expansion.

Sintered-Metal Joints

Of all the joints already mentioned, transition joints of the Firth-Brown type with intermediate coefficients of expansion appear to offer, from the theoretical point of view at least, the optimum solution, as they provide a graduated transition between two metals with different coefficients of expansion. Whilst they reduce to one quarter the stresses due to the differential expansion of the ferritic and austenitic elements, these stresses could, however, be virtually eliminated completely by the use of transition joints whose chemical composition changes smoothly from ferritic at one end to austenitic at the other. Such a joint could be manufactured by powder-metallurgy techniques.

Fig. 10 shows a hypothetical joint of this type, together with the coefficients of thermal expansion of the joint and the corresponding chemical compositions. The varying wall thickness of the joint takes into account the different hot strengths of the austenitic and ferritic steels used. As can be seen, the chemical composition of section A–A, adjacent to the ferritic weld, contains 50% Ni, 10% Cr, and 10% Co, with a coefficient of expansion of 14×10^{-6} per °C, while at section C–C, adjacent to the austenitic weld, it is similar to that of an 18/8 Cr/Ni steel, with a coefficient of expansion of 14×10^{-6} per °C. Between these sections, the composition changes progressively in accordance with the coefficient of expansion, so that, for instance, at section B–B, it contains about 40% Ni, 12% Cr, and 4% Co, with a coefficient of expansion of about 15×10^{-6} per °C. This gradual transition from one composition to another could be achieved by appropriate mixing techniques.

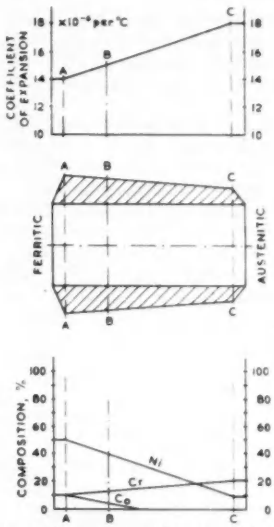


Fig. 10. Sintered-metal joint, showing different coefficients of expansion and corresponding chemical compositions.

Progress in powder-metallurgy techniques has in recent years been so rapid that the production of such sintered transition joints with the desired high-temperature properties may well be possible in the near future.

ROUMANIA

A Qualitative Separation of Wear Factors

By L. Rozeanu and O. Preotescu. (From *Revue de Mécanique Appliquée*, Vol. 2, No. 1, 1957, pp. 115–127, 10 illustrations.)

It is well known that the great difficulty in studying wear phenomena is the identification and separation of the wear factors concerned. For the sake of simplicity, it is necessary to separate a limited number of prominent or fundamental types of wear which can explain the various forms of complex wear ; in this connection, it seems reasonable to list four fundamental types of wear, which may be termed adhesive wear, abrasive wear, corrosive wear, and fatigue wear respectively.

Adhesive Wear

Adhesive wear or, strictly speaking, adherent friction, has been largely, though not exhaustively, studied by various authors, and the basic conclusions about it can be summed up as follows :—

(1) Adhesion is the result of a metallic contact which in practice cannot be avoided, even under the most perfect hydrodynamic conditions or under virtually insignificant loads.

(2) Adhesion is more pronounced between those metals which give solid solutions at room temperatures.

(3) Adhesion is conditioned by the absence or collapse of an interposed film.

(4) The resulting metal transfer usually, but not always, proceeds from the softer to the harder surface.

(5) True adhesion has a linear relationship with the mechanical properties of the materials concerned, as well as to their coefficients of friction. This relationship can be expressed as $f = \tau/\sigma_c$, where f is the coefficient of friction, τ the shear strength, and σ_c the yield strength of the softer metal.

Despite the experimental evidence furnished by various authors, the physical meanings of the processes involved in adhesive wear are rather obscure, so that this theory cannot satisfactorily explain certain quite common phenomena. For instance, it does not explain why, in cutting metals, a built-up edge does not form under any conditions on the tool, although the compressive stress is high and the metals in contact (the chip and the tool face) are cleaner and in more intimate contact than metallic surfaces usually are during the friction process. Similarly, it does not explain why, when welding or soldering two metals, quite complicated procedures are necessary for cleaning and heating, and, even then, only certain pairs of metals can be made to adhere. It does not explain why, for each set of conditions, a certain real area of contact is necessary which can often support a load many times higher than that predicted by theory, and that the presence of any lubricant, even water, can greatly increase the real area of contact.

The available evidence, while qualitatively confirming the existence of this fundamental type of wear, points towards a more complex explanation; moreover, adhesive wear should manifest itself only when the hardened

asperity, after some fatigue work (which should be quite ample, if the frequent interlocking inherent in compressive sliding is considered) arrives at its fatigue limit and, owing to a new collision with another asperity, breaks off. That is why it is reasonable to conclude that adhesive wear by itself makes a minor contribution, in comparison with other fundamental types of wear, but that the metallic contact has a great influence on other fundamental types of wear, particularly on corrosive and on fatigue wear.

Abrasive Wear

Abrasive wear may be considered as the result of surface asperities and hard contaminants, but, here again, although numerous experimental data and theories are available, very few are really closely related to what actually happens during the process of abrasive wear. It has, however, been proved that there is a perfect similarity been abrasion and metal cutting, so that the process of abrasive wear can be treated as a conventional cutting process.

The present state of knowledge concerning abrasive wear is somewhat erratic and is based mainly on practical observations, which can be summarized as follows :—

(1) For abrasive wear to take place, a certain minimum normal load is required ; in the case of steel, this is about 30 kg/cm^2.

(2) The controlling factor in abrasion is the relative hardness of the two materials concerned. Even when the particle hardness is very high, as in the case of quartz, the traces left by abrasion are only 2 to 3 cm in length, because the cutting edges of the hard particles are easily broken.

(3) To avoid abrasion, the particle size must always be smaller than the thickness of the lubricant film ; in the case of motor-car engines, the particle size is about 25 μ, indicating violent abrasive wear, because minimum lubricant thickness does not usually exceed 5 μ. The object is to bring the particle size down to 1 μ, considered to be no longer dangerous.

(4) The abrasive particles destroy the integrity of the surface, particularly when the action is one of slow plastic strain. At the same time, they raise the thermal level of the friction process and generate tensions, some of which may well affect the future life of the superficial strata.

(5) When the abrasion process is very rapid and implies a very small amount of plastic strain, it is possible to obtain smooth surfaces with practically no internal stresses. This is the theoretical basis of good grinding practice.

(6) Abrasive wear is dangerous not only in itself, but also as a powerful auxiliary of corrosive and fatigue wear.

Corrosive Wear

The chemical processes of corrosion under static conditions are quite well known and are satisfactorily understood. However, as soon as conditions cease to be static, the process becomes complicated and obscure, when the number of reacting agents exceeds three or four.

The basic principles of corrosive action are simple and may be summarized as follows :—

(1) All pure metals react with atmospheric oxygen, and the resulting oxides react with the available acids, producing corresponding salts or soaps.

(2) For obtaining such a chemical reaction, a metal, oxygen, water, and an acid are usually required. The first three are always present, while the fourth can easily be made to appear after various reactions of the lubricant or fuel components. Some of these reactions need great activation energy, being slow reactions with a passivating effect. Some others, on the contrary, do not need any activation energy ; they progress all the time, the rate of reaction depending on the rate of diffusion of the active compound towards the metallic surface and the rate of diffusion of reaction products from the site of reaction towards the surrounding medium.

(3) The critical factor of corrosive action is temperature, but dynamic conditions greatly increase the rate of reaction by increasing the rate of diffusion of reacting substances and reaction products.

It should be emphasized that mild corrosion is, strangely enough, a powerful auxiliary in the fight against wear. When such a process takes place, the reaction products do not easily leave the metallic surface, but form a chemisorbed layer on it. The strength of this layer is of importance. Very probably, prior to the formation of a chemisorbed layer, an adsorbed layer will be formed, with a tangential strength of the same order of magnitude, but with an adhesive strength from about 10 to 100 times smaller.

The benefit of the chemical action cannot be obtained immediately. When a chemically active compound is interposed between two metallic surfaces in close contact, and when the activation energy of the reaction is great, no reaction will take place until the necessary quantity of heat is furnished from some source. If two bodies are compressed, the source of heat is the plastic strain. Consequently, it is possible to detect the chemical reaction by its irreversible effects. For instance, if the compressive stress is greater than the strength of the chemisorbed layer but just below that required for plastic deformation, an electrical method will indicate a certain true area of contact. As the plastic deformation is a heat source, it necessarily follows that, by further increasing the experimental stress, this will determine a chemical reaction, whose final result will be the dissolution of the summits of higher asperities, leaving flattened surfaces and a greater true area of contact.

Naturally, pronounced corrosive action has a very dangerous and powerful influence on wear, but mild corrosive action, as already mentioned, can be a useful factor in limiting wear, if properly controlled. There can be no doubt, however, that a better understanding of the chemistry of wear is essential, and further research will eventually show many new aspects of the advantages to be derived from mild corrosive action.

Fatigue Wear

It has already been shown that adhesive wear, though inevitable, is of relatively minor importance, that abrasive wear can be avoided, and that mild corrosive wear, if properly controlled, is actually of benefit in minimizing the effects of wear. Fatigue wear, however, is probably by far the most active fundamental type of wear. Fatigue, resulting in an accidental fracture of materials subjected to some kinds of cyclic stresses, is well known, but fatigue, as a superficial manifestation of similar types of cyclic stresses, is not so well known. Certainly, the least known form of fatigue is that involving a superficial loss of minute amounts of material, in which asperities become loosened by fatigue.

It is easy to understand that fatigue commences with the first machining operation and penetrates to a greater depth with more violent machining processes. Fatigue is

closely related to the plastic deformation of the material, and has been shown to attain a depth of from 20 to 80 μ. For fatigue wear, the state of strain is a favourable medium, and repeated stress is an active factor, though how the process develops is rather hard to say, and may well be quite complex. However, bearing in mind that fatigue commences with the first machining operation and that, in any sliding action, every surface asperity is bound to come into more or less violent collision with innumerable opposed asperities, it is natural to accept the supposition that at any given moment the material in some asperity has attained its fatigue limit and is ready to leave the surface as a wear particle which will eventually be embedded in the opposite surface, in the same way as a transferred particle.

Such a hypothesis (and it is very difficult to contest its possibility) explains the known contradictory facts, even the surprising one that, for material transfer through adhesion, the load need not be greater than a few grams, while the material is able to support considerably larger loads under an elastic strain.

Under the normal running conditions of engines and industrial machines, fatigue wear should not be considered a critical problem. In the short operational periods involved, it can manifest itself only when the construction is not rigid and when contaminants of an acidic nature enlarge the minute superficial cracks of the material, propagating them to greater depths and over larger surfaces. Usually, friction and mild abrasion perform their continuous destructive work, up to the same depth and with the same rate of progression.

The particular forms of fatigue wear called pitting, fretting corrosion, cavitation, etc. are obvious consequences of specific cyclic actions on materials with incipient faults or of a non-homogeneous nature.

Every conceivable wear factor can speed up and intensify fatigue wear. Corrosion has been shown to promote fatigue wear ; abrasion is frequently the cause of surface cracks ; adhesion, or rather the metallic contact, furnishes the repeated necessary stress ; temperature intensifies the chemical reactions ; pressure increases plastic strain ; vibration in itself is a cause of fatigue ; electrical processes can supplement chemical processes ; and so on.

The task of probing deeper into this matter is a difficult one, considering what is known about the physical meaning of fatigue phenomena. The only thing certain is the conclusion that the fight against fatigue wear must start in the shop where the components are built. From there, it must continue through the whole life of the machine, with increasing intensity, until finally further action becomes uneconomical.

Wear and Time

When discussing wear, the situation is usually considered unchanged from the very beginning, when the engine or machine is assembled, until all the parts are badly worn out and many disturbing factors impose themselves on normal working conditions. As such, it would be more correct to consider three sets of conditions, i.e., (1) initial conditions of standard matched surfaces (statistical normality of matching), (2) normal conditions of run-in surfaces (true normal or corrected matching), and (3) final conditions of abnormal harmful interferences.

Initial Conditions:—

In spite of painstaking studies trying to prove the great merits of very smooth surfaces, the experimental evidence is quite confused. It is definitely established that the important scope of the running-in process is not the smoothing of surfaces. It can be shown experimentally that, when some conventional measuring directions are adopted, the loss in weight does not correspond to dimensional variations, but nearly always to semi-microgeometrical faults or nonconformities, and these are located along the directions of measurements only in exceptional cases.

The same conclusion can be obtained theoretically by making the following assumptions :—

(1) The heights of asperities are distributed, in conformity with Gauss's law, around a mean value I_{med}, with a minimum value of 0·1 μ and a maximum I_{max} of 3·6 μ (the usual values for fine grinding), as shown in Fig. 1, in which X_{max} is the maximum deviation from the mean value of the heights of the asperities, Z is the depth of running-in wear, and $\varphi(x)$ is a function of X_{max} and $(X_{max} - Z)$, expressing the areas of the distribution curves for the range $\pm X_{max}$ and $\pm(X_{max} - Z)$.

(2) The mean square deviation σ is 0·75.

(3) The asperities have the aspect of prisms of triangular cross-section.

(4) The apparent initial contact area is 10,000 times the true initial contact area.

(5) The apparent final contact area after running-in is 200 times the true final contact area.

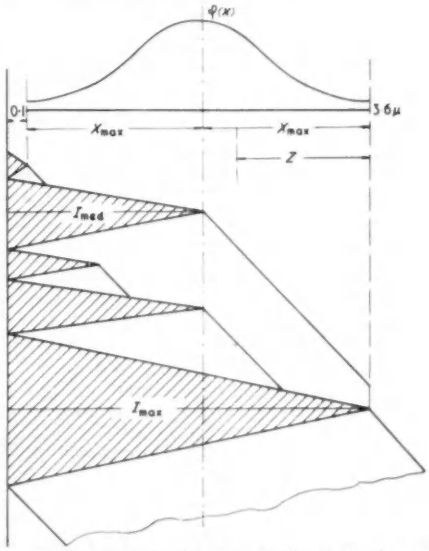


Fig. 1. Schematic representation of the distribution of surface micro-asperities.

Based on this Gaussian distribution of micro-asperity heights, it is possible to calculate the effective supporting area and the weight of material lost in terms of depth of wear. These are shown graphically in Figs. 2 and 3 respectively. In actual fact, when passing from a true contact area of about 1/10,000 that of the apparent contact area to a final true area of about 1/200 that of the apparent area, the necessary depth of running-in wear is about 0·4 μ, representing about 0·009 gram of iron for a total apparent friction surface of about 1m². If the wear particles are uniformly distributed in from 5 to 10 kg of oil, it is easy to understand that practically no quantitative

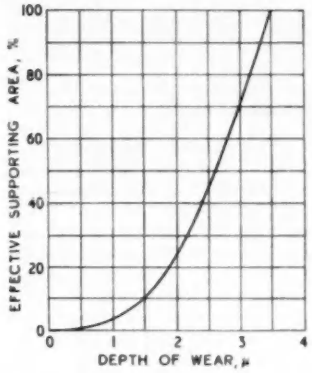


Fig. 2 (above). **Effective supporting area as a function of depth of wear for a normal (Gaussian) distribution of micro-asperity heights.**

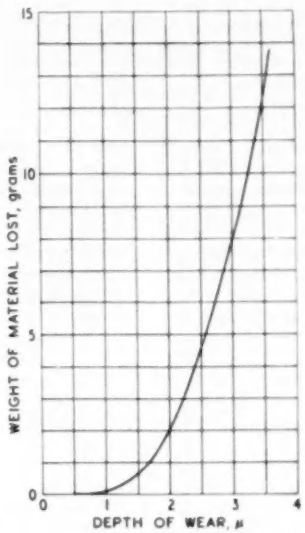


Fig. 3 (right). **Weight of material lost as a function of depth of wear, from a surface of 1m², for a normal (Gaussian) distribution of micro-asperity heights.**

analysis will be able to detect them. In crank-case oil taken from an engine after the running-in period, analysis has shown from 20 to 40 milligrams of iron per 100 grams of oil, i.e., a concentration which is about 100 times greater. It is therefore evident that this iron has been produced by some process other than the smoothing out of surfaces, very probably by the wearing out of some semi-microasperities or some other rather considerable nonconformities.

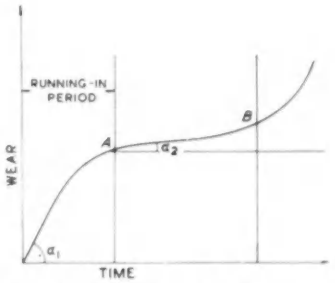


Fig. 4. **Conventional schematic representation of wear as a function of time.**

This conclusion is of great importance for the correct understanding and development of the running-in process, and postulates that running-in is practically unnecessary when the machine components are well made and correctly assembled. On the other hand, running-in is necessary to correct semi-microgeometrical faults normally too small to be detected in the factory but too large for normal operation. The same can be said about faulty assembly operations. Running-in should not affect the entire friction area but only local points where considerable plastic deformation and abrasion will take place. To ease the action, bearing in mind its large volume, the surface should have a certain roughness, depending on the number and magnitude of local faults, i.e., determined by the design and the quality of the work. This means that surfaces can be smooth on a molecular scale only when design and execution are perfect. To face the heavy loads imposed by the elimination of faults without damaging the materials, the lubricant should have, first of all, very good anti-welding properties; the other quality conditions are of secondary importance. Finally, it results that running-in should be effected, for a convenient period of time, at the maximum load expected to be met with in normal operation, as this represents the criterion for determining permissible deviations.

Normal Conditions :—

The conventional wear diagram (Fig. 4) has a central portion *AB* which can be considered practically as a straight line. The angular coefficient of the line is $\tan \alpha$ and its value is determined by running conditions, but no known criteria are available for determining α. If a practical statistical basis is taken as acceptable, it is possible to consider that, during the period *AB*, wear does not differ much for various machines of different sizes. This conclusion is, indeed, accepted when standardizing the successive dimensions of the spare parts. The fact is explained by the observation that small machines wear more quickly than large machines. Nevertheless, if the law of wear is linear, then wear should not be affected by the change in conditions in a given range, and physically this cannot be true. Probably it means that, on a wide-scale statistical basis, it is possible to conceive a conventional range of mean conditions as the result of a large number of compensating factors. So far, no simple treatment of this aspect of wear can be presented.

Final Conditions :—

The useful life of a machine is limited by economical considerations, and there comes a moment when performance is no longer satisfactory, when the power loss is too great, and when noise and vibration are unbearable. These may be called the worn-out or final conditions. From a practical point of view, a study of these conditions would not be particularly profitable in the material sense, but it would be extremely interesting if it could lead to a better understanding of those factors which, although less developed than others, still play a part in the normal range of mean conditions.

From the point of view of quality, it can be stated that the most important controlling factors are boundary friction, uncontrollable vibrations, and fatigue of materials. Boundary friction may be harmless, but the combined presence of complex vibrations and fatigued materials is evidently a critical cause of damage. The proportion of normal periodically acting surface stresses grows all the time, and consequently conditions are more favourable for cavitation and pitting phenomena. Moreover, the fatigue accumulated in materials lowers the resistance of machine parts, and from time to time large cracks or dislocations may appear quite unexpectedly.

A correct explanation of the phenomena taking place under final conditions will be essential, when better knowledge of the other two types of wear has been acquired.

JAPAN

New Oxidizing Method, using Borax, for Revealing Austenitic Grains

By Y. IMAI and H. HIROTANI. (From *The Science Reports of the Research Institutes, Tôhoku University*, Series " A ", Vol. 9, No. 6, December 1957, pp. 467–475, 13 illustrations.)

EVERY method of revealing primary austenitic grains is based on the fact that grain-boundary materials, in general, have greater chemical and physical activities than the grains themselves. Since the introduction of the carburizing method for revealing austenitic grains in steel, three methods have been evolved, i.e., thermal etching, fracture, and martensitic etching. These methods do not introduce carbon or oxygen into the steel, but they have their limitations, insofar as normal applications are concerned. Thus, thermal etching leaves almost unchanged the grain boundaries formed at the immediately preceding growth, while the fracture method may have a tendency to show a somewhat large grain in the case of duplex structures, and the martensitic method is usually difficult and inaccurate with some steels.

Another method of revealing primary austenitic grains is the oxidizing method and, although it introduces oxygen into the steel, it has the advantage of showing a distinct microstructure. This method may be divided into two categories, in one of which the specimen is heated and oxidized in air, and in the other it is heated in a vacuum and then slightly oxidized for colouring the austenitic grains. In the first method, no heating in a vacuum is required, but it has the disadvantage that considerable skill is required in repolishing the surface of the specimen, to safeguard against the possible disappearance of the grain boundaries. In the second method, after heating in a high vacuum to the austenitizing temperature for a suitable period, the specimen is allowed to oxidize for a very short period of time, and is then quenched rapidly. Here, the disadvantage lies in the difficulty of controlling the exact degree of oxidation required for various types of steels.

When the specimen is exposed to air at high temperatures for a short period, the austenitic grain boundary is usually more oxidized than the matrix. It has been found, however, that, when a specimen oxidized in this way is dipped into molten borax, the thin film of oxide dissolves in the borax, and the grain boundary appears clearly as a thin line. In this case, decarburization may be practically negligible, as exposure is only of a few seconds duration. The use of borax is therefore the basis of a new method for revealing austenitic grains easily.

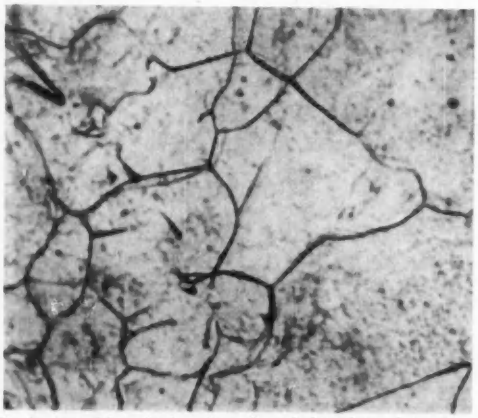


Fig. 1. Austenitic grains in a thermally etched specimen of pure iron. (×110)

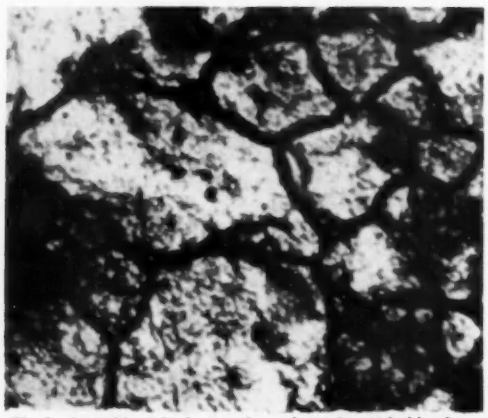


Fig. 2. Austenitic grains in a specimen of pure iron etched by the new method. (×110)

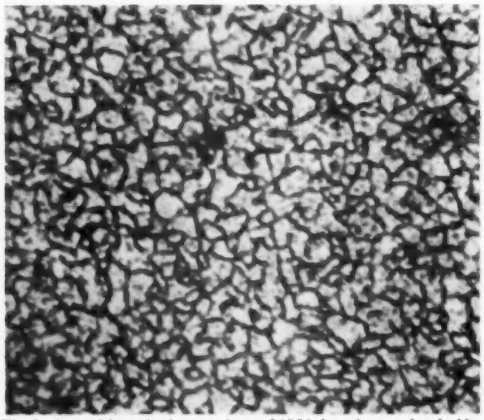


Fig. 3. Austenitic grains in a specimen of 10% chromium steel etched by the new method. (×110)

With this new method, the surface is polished, and the specimen is then heated in a high vacuum and held at the austenitizing temperature for a suitable period, e.g., 1000°C for from 1 to 3 hours. The specimen is then permitted to oxidize for from 3 to 5 sec by introducing air into the furnace, after which it is immersed in molten borax heated to between 900 and 950°C in a graphite container, stirring for from 30 to 45 sec to dissolve the thin film of oxide in the borax. Finally, the specimen is quenched in water, so as to enable the borax film to be removed easily, exposing a clean surface. After washing and drying, the specimen can be examined under the microscope, with or without slight repolishing. Thus, the new method is technically simple to carry out, and tests have shown that it provides a consistently reliable means of examining austenitic grains in steel.

Tests have been carried out on iron and steel of different compositions, including carbon steels, chromium steels, nickel steels, manganese steels, and chromium-molybdenum steels. In all cases the results obtained were satisfactory and permitted accurate determination of grain size.

As an example of the improved results obtained with the new method, Fig. 1 shows austenitic grains in a specimen of pure iron, thermally etched after holding at 1000°C for 3 hr and then air-cooling in a vacuum, while Fig. 2 shows the results obtained with a similar specimen, austenitized at 1000°C for 3 hr and then immersed in borax at 900°C for 30 sec. From these results, it will be seen that, with thermal etching, the previous grain boundaries are almost unchanged, thereby complicating observation. On the other hand, with the new method, only those boundaries formed during oxidation are visible.

Similar satisfactory results were obtained with the other steels investigated, even with steels of high chromium content, which become covered with a thin and strongly adherent film of chromium oxide when exposed to air at high temperatures. Fig. 3 shows the results obtained with a 10% chromium steel, austenitized at 1000°C for 3 hr and immersed in borax at 900°C for 30 sec.

It is, of course, known that austenitic grain size is influenced by the amount of dissolved nitrogen present.

(Concluded on page 121)

SWITZERLAND

Abrasive-Erosion Phenomena in Hydraulic Turbines

By T. Bovet. (From *Schweizer Archiv*, Vol. 23, No. 12, December 1957, pp. 377–388, and also *Bulletin Technique de la Suisse Romande*, Vol. 84, No. 3, February 1, 1958, pp. 37–49, 24 illustrations.)

In the operation of hydraulic turbines, abrasive erosion, which occurs as a result of the presence of solid particles in the water used, is of importance, all the more so because most sources of such water contain more or less considerable amounts of sand or gravel.

A characteristic of surfaces subjected to abrasive erosion is that they retain their relatively smooth appearance, but show wavy lines or ripples occasioned by the abrasive action. Since these waves are associated with small radii of curvature, it should be noted that their troughs will be accentuated, i.e., made deeper, as erosion progresses, while their crests will remain unaffected.

In this paper, which was presented at the conference held by the Swiss Association for the Testing of Materials (A.S.E.M.) on September 6, 1957, examples are given of some of the damage caused by abrasion to various types of hydraulic turbines, together with details of measures for preventing or minimizing such damage.

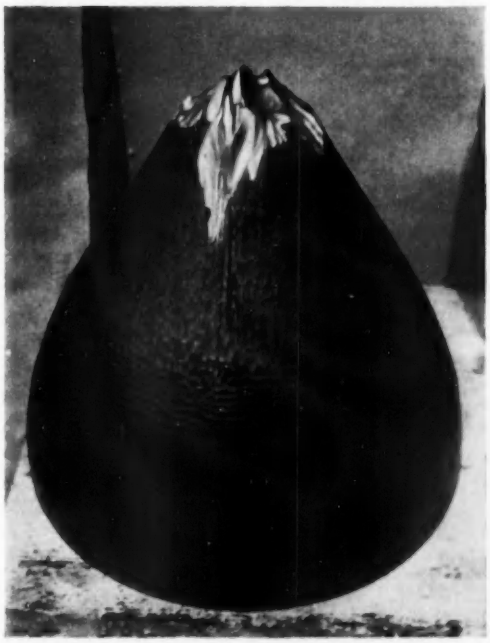


Fig. 1. Erosion of a needle from a Pelton-type impulse-turbine nozzle.

Impulse Turbines

With Pelton-type impulse turbines, in which a high-pressure jet of water impinges on the buckets of the wheel, the main components likely to be subjected to abrasive erosion are the nozzle, especially its outlet annulus, and the needle-valve or spear which controls delivery to the turbine by axial displacement. In the fully open position, the entrained particles of sand or gravel are deflected towards the centre by the taper of the nozzle and impinge on the tip of the needle, subjecting it to severe attack from high-velocity impact and abrasive action. At the position of minimum opening, impact on the tip of the needle no longer takes place, and only abrasive action exercises any further effect. An example of a badly eroded needle from an impulse turbine, operated with a head of 540 metres, is illustrated in Fig. 1, which shows clearly the destruction of the tip of the needle from sand impact and the wavy patterns produced on the larger portion as a result of abrasive erosion.

In impulse turbines, the buckets are usually of double-lobe form, comprising two cavities coming together in a common splitter. As the water is divided into two separate jets and diverted by the splitter through a wide

Fig. 2. Example of erosion of a Pelton-wheel bucket.

angle, abrasion of the Pelton-wheel buckets is inevitable if particles of sand are present in the water. Fig. 2 shows an example of a double-lobe bucket, in which can clearly be seen the erosive action of sand particles on the right-hand lobe, after operating for a period corresponding to less than two summers (when the sand content of the water is at its highest). For comparison, the left-hand lobe is shown after welding over and grinding to restore it to its original shape and surface finish.

Other examples of erosion of Pelton-wheel buckets by a high sand content in the water, especially during the summer, are shown in Figs. 3 and 4, and clearly indicate the attack experienced on the buckets and on their entrance edges and splitters. The bucket in Fig. 3 is of manganese steel and had been in operation for nearly 6100 hours, of which about 4000 hours were during the summer months. The bucket in Fig. 4, from the same power station, was of a 2% nickel steel and had been in operation for about 4000 hours, almost entirely in the summer. As shown in the illustrations, there is no appreciable difference in the amount of wear experienced, despite the different compositions of the two buckets.

Investigations carried out in connection with a 22,000-kW hydroelectric unit have established the adverse effects on efficiency caused by erosion of the needle and nozzle of Pelton-type turbines. Thus, it was found that, after 8200 hours operation, abrasions of from 0·5 to 1 mm in depth on the needle and nozzle of this turbine caused a drop in efficiency ranging from 1·5% at full load to as much as 9% at one-quarter load. This drop in efficiency is due to the defective formation of the resulting jet, which is dispersed by the asperities of the eroded surfaces, so that it is split up into a number of jets which do not act efficiently on the wheel.

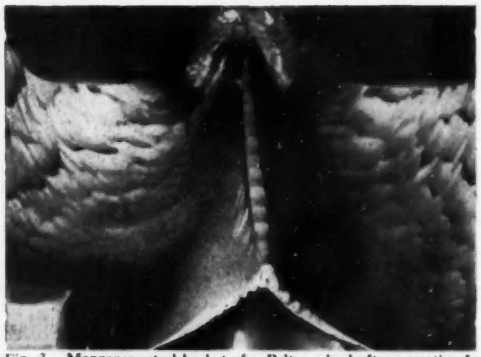


Fig. 3. Manganese-steel bucket of a Pelton wheel after operation for nearly 6100 hours, mainly in the summer.

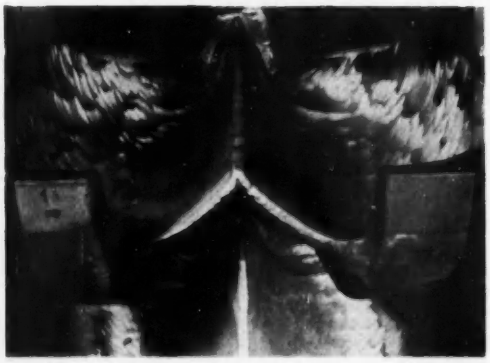


Fig. 4. Nickel-steel bucket of a Pelton wheel after operation for 4000 hours, almost entirely in the summer.

Francis Turbines

As a typical example of the kind of erosion likely to be experienced by Francis turbines, it is interesting to note the experience obtained with two 10,000-hp horizontal-type units operating at 750 rpm with a head of 177 metres and a flow of 4·92 m^3/sec at the Martigny-Bourg power station in Switzerland. The water supplying these turbines has a sand content which is of a crystalline, highly abrasive type, and which reaches appreciable proportions, especially during the summer months. Thus, despite the use of sand-removal equipment capable of eliminating sand particles with a grain size greater than 0·4 mm, measurements taken during the summer have shown that the residual sand content of the water passing through this plant varies between 30 and no less than 2200 tons per day, this maximum value corresponding to about 3 grams of sand per litre of water.

Fig. 5. Guide case of a Francis turbine after 3684 hours operation in the summer.

Of the two turbines under consideration, one was stripped for inspection after a total of 4623 hours operation during winter periods, and the other after 3684 hours operation during the summer months. Damage due to erosion in the latter turbine was very appreciably greater than that in the former, despite its considerably shorter period of operation. In both turbines, the components mainly affected were the guide case, the guide vanes, and the runner. There were virtually no signs of wear on the cast carbon-steel guide case of the turbine run for 4623 hours, whereas the other, as shown in Fig. 5, was badly eroded, with the formation of grooves which in some places were from 10 to 12 mm deep.

Similarly, while the cast carbon-steel guide vanes of the turbine run during the winter months showed hardly any traces of wear, those of the other turbine were, as shown in Fig. 6, considerably eroded, particularly at

points where secondary flows were created as a result of pressure differences on the two sides of the vanes.

Insofar as the runners of these turbines are concerned, these are of stainless steel, containing 13% chromium and from 0·5 to 1% nickel, and, here again, while the runner of the turbine operated during the winter months was practically unmarked, that of the other turbine (Fig. 7) suffered extensive abrasive action. Thus, a reduction of 6 mm in vane thickness over the entire length was noted,

Fig. 6. **Guide vanes of the Francis turbine referred to in Fig. 5, after 3684 hours operation in the summer.**

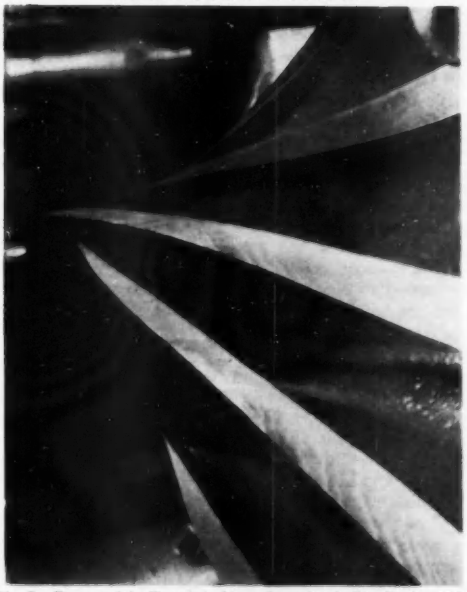


Fig. 7. **Runner of the Francis turbine refrerred to in Fig. 5, after 3684 hours operation in the summer.**

Fig. 8. **Damage from sand abrasion to the runner of a 40-hp Francis turbine.**

together with the formation of grooves running in the direction of flow and attaining a depth of from 2 to 3 mm at the exit end on the pressure side. It is interesting to note that no signs of erosion were observed on the backs of the vanes and that the vane sections facing the casing, although having a polished appearance, showed amounts of wear not exceeding 0·3 mm, although the wear of the casing itself at these points reached up to 2 mm.

Finally, a striking example of the kind of damage which can be occasioned by sand abrasion is illustrated in Fig. 8, which shows the runner of a small 40-hp Francis turbine operated for some time with water containing an appreciable quantity of very hard sand.

Kaplan Turbines

Because of their high relative velocity coefficients, most of the wear occasioned in Kaplan turbines is on the propeller, especially on the backs of the blades.

Fig. 9 is an example of the erosion produced in the propeller of a Kaplan turbine, in this case after 18,700 hours operation with water containing a high content of fine sand and having a flow velocity over the blades of more than 40 metres per second. The illustration shows the backs of two blades, and it will be noticed that, whereas the inner surfaces, i.e., near the hub, are virtually free from any trace of wear, the characteristic signs of sand erosion are evident at the outer surfaces. The wear experienced at the blade edges is still further accentuated by the presence of secondary currents, which tend to maintain pressure equilibrium between the front and back surfaces of the blades.

Preventive Measures

There are two main types of measures which can be applied for prevention of erosion in hydraulic turbines, one of which is to deal with the problem at its origin by endeavouring to eliminate, at least partially, the sand content of the water before it reaches the turbine. For this purpose, sand-removal systems can be of considerable help, but it should be remembered that, although they can remove a considerable quantity of solid material, they cannot eliminate all suspended particles, and, in fact, an appreciable amount will still be present in the water supplied to the turbine.

The second preventive measure, generally used in conjunction with the first, is to increase the resistance to erosion of the turbine by the use of special metals or alloys for all vulnerable parts. Progress in this direction can be obtained only by extensive tests, not only in the laboratory, but also on actual turbines under industrial operating conditions.

In view of the highly abrasive nature of most particles of sand, periodic inspection (averaging about once per year) of turbines exposed to appreciable erosive action is essential, and there can be no doubt that the choice of suitable erosion-resistant materials is of great importance. In this connection, experience indicates that, for runners, good results are obtained with a 0·4% carbon steel containing 1·5% manganese, and with a 0·25% carbon steel containing 2% nickel and 0·7% manganese. Both these materials have a tensile strength of about 60 kg/mm² and excellent welding properties—an important consideration insofar as ease of maintenance is concerned.

On the other hand, experience with the use of stainless steel containing about 13% chromium for runners subject to erosive conditions has proved rather disappointing, inasmuch as its resistance to wear is not markedly superior to that of the steels mentioned above, and certainly not commensurate with the fact that it is about 50% more expensive. Furthermore, while stainless steel can be welded, it should be noted that a zone of extreme hardness is formed between the base metal and the weld metal, making subsequent machining operations more difficult.

With regard to the needles and outlet annuli of the nozzles of Pelton-type turbines, good results have been obtained by providing these components with an electrolytically deposited 0·2-mm layer of hard chromium (Rockwell hardness = 70 to 72 kg/mm²), and it appears that this protection is efficient, provided that the sand content of the water does not exceed 0·05 gram per litre. As an example, a needle treated in this way still had, after about 26,800 hours service, what could be regarded as a polished surface, the only apparent defect being a circular mark which was, however, due to excessive contact pressure between the needle and the nozzle in the closed position. This difficulty was easily overcome by increasing the contact area, thus reducing the specific contact pressure, and subsequent tests incorporating this modification proved eminently successful, as can be seen in Fig. 10, which shows a needle of this type after nearly 51,700 hours service, though admittedly in this case the water had a relatively low sand content.

Fig. 9. Two blades of the propeller of a Kaplan turbine after 18,700 hours operation.

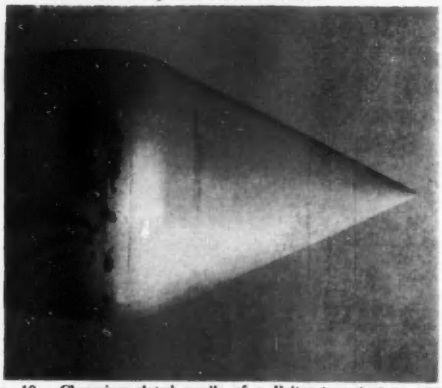


Fig. 10. Chromium-plated needle of a Pelton-type turbine nozzle, after nearly 51,700 hours operation.

Where the sand content is higher than 0·05 gram per litre, good results have been obtained with a Cr-Ni-Mo steel having a tensile strength of 150 kg/mm². For large needles, it is considered advisable to use a weldable steel, so as to facilitate repairs and to avoid having to replace the entire component. There is, however, little advantage to be gained in this connection if the diameter of the needle is less than 30 cm.

In the case of the outlet annuli of nozzles, repairs are not very practicable, so that these components should be made of high-strength steel. Recent tests have shown satisfactory results with a special stainless steel containing 0·8% C, 18% Cr, and 1·8% Mo.

In connection with repairs to Pelton wheels, these can be divided into two types, i.e., (1) the welding over of small defects in the lobes and splitter of the buckets, with subsequent grinding and polishing, and (2) the welding of new material over the entire surface of the buckets, so as to restore them to their initial thickness. Repairs of the first type can be effected easily, but those of the second type are major operations, requiring preheating of the buckets and subsequent annealing for stress relief. Nevertheless, it should be understood that the cost of a major repair of this type is far less than that of a new wheel, though, of course, such repairs cannot be repeated indefinitely.

With regard to Francis turbines, it is considered advantageous to utilize ordinary steels for the guide case and other elements subject to erosion, with the exception of the guide vanes and the runner, the reason being that most of these components are difficult to repair and, to maintain high turbine efficiency, it is preferable to replace them periodically by new components. In any case, the higher expense incurred by using stainless steels would not, in the circumstances, be warranted.

Heat Transmission through Fins and Finned Cylinders

By K. LÖHNER and G. CHONÉ. (From *MTZ*, Vol. 18, No. 12, December 1957, pp. 373–377, 15 illustrations.

In this paper, the rather scattered data on heat-transfer calculations for fins and finned cylinders are evaluated and expanded by newly computed nomograms and are arranged to suit modern requirements. Equations and nomograms necessary for heat-transfer calculations under various conditions are presented, and special consideration is given to the determination of fin dimensions for optimum heat transfer.

THE amount of heat to be dissipated through the cylinder walls of internal combustion engines is in the region of 200 to 600 kcal/hp-hr, or even higher in some cases. Air as a cooling medium has the disadvantages of a low heat-transfer coefficient and low specific heat ; consequently, in designing air-cooled engines, special attention must be paid to heat-transfer coefficients and to heat-transmitting surfaces.

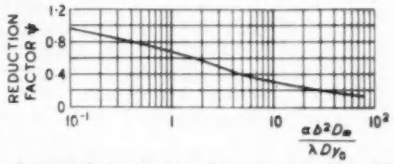


Fig. 1. **Reduction factor ψ to be used in conjunction with eq. (1).**

Cooling fins increase the area of the surfaces enabling heat exchange to take place. It has been shown theoretically by Schmidt[1] that a fin with a parabolic contour has the most favourable shape for a minimum weight of material and that a triangular fin is only slightly less effective. However, Schmidt's calculations assume that the heat-transfer coefficient has the same value over the entire surface, and in actual fact this is not the case, as it is dependent on air velocity and incident flow conditions. The importance of these two factors has been amply demonstrated by Löhner, who also developed equations for the heat dissipation from a cylinder with fins of triangular section.[2] For both uniformly and irregularly spaced fins, simplified calculations of the degree of heat transfer obtainable have now been evolved, the corresponding evaluation procedure being as follows :—

The heat Q dissipated from a finned surface is given by

$$Q = -2\alpha\, b\, \pi\, D_m\, \psi\, \Delta T \quad .. \quad .. \quad (1)$$

where α = heat-transfer coefficient [kcal/m²hr°C], b = depth of fin [m], D_m = mean fin diameter [m] (= $D + b$, where D = outside diameter of cylinder), ΔT = difference in temperature between the cooling air and the root of the fin [°C], and the reduction factor ψ, obtainable from Fig. 1, is

$$\psi = f\,[\alpha b^2\, D_m/(\lambda D y_0)] \quad .. \quad .. \quad (2)$$

where λ = thermal conductivity of the metal used [kcal/m hr°C], and y_0 = half the fin thickness at the root of the fin [m]. Generally, when no other specific data are available, the value of α can be taken as 38·7 for steel, 50 for cast iron, 137 for aluminium, 324 for copper, and 133 for magnesium. With flat fins, D/D_m can be taken as unity.

The cooling effect ε, i.e., the heat removed [kcal/m² hr°C] from the area of the plain cylindrical surface, can be evaluated from

$$\varepsilon = \frac{\alpha}{s+t}\left[\sqrt{\frac{2\lambda t}{\alpha}}\left(1+\frac{b}{D}\right)\times \tanh\left\{\sqrt{\frac{2\alpha}{\lambda t}}\left(b+\frac{t_m}{2}\right)\right\}+s\right] \quad .. \quad (3)$$

where s = spacing between the fins [m], t = fin thickness [m], and t_m = mean fin thickness [m]. This equation, evolved by Biermann and Pinkel[3], is based on permissible simplifications and is a development of Schmidt's equation for a rectangular flat fin.

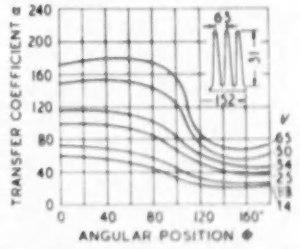


Fig. 3. **Distribution of heat-transfer coefficients α around a finned cylinder of 118 mm diameter at different angular positions Φ.**

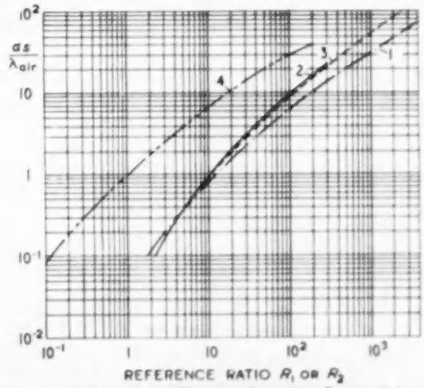


Fig. 2. **Heat-transfer coefficients α for various flow conditions.**

Now, the value of the heat-transfer coefficient α is required for both eqs. (1) and (3). Investigations to determine values of α for various flow conditions and fin arrangements have been carried out by N.A.C.A. in the U.S.A. Four basic types of flow conditions have been considered, i.e., (1) free incident flow, (2) free incident flow with baffles, (3) free incident flow at 45 deg. to the cylinder axis, and (4) fully ducted cylinders. The corresponding results, with $\alpha s/\lambda_{air}$ plotted against a suitable reference ratio, are shown in Fig. 2, in which curve (1) refers to a cylinder with free incident flow, curve (2) to free incident flow with 140-deg. baffles, and curve (3) to free incident flow at 45 deg. to the cylinder axis. In these three cases, the reference ratio R_1 is taken as

$$R_1 = \frac{V\gamma_1 s^2}{\nu\gamma_0\, D^{0.25}\, b^{0.45}} \quad .. \quad .. \quad (4)$$

where V = velocity of incident flow [m/sec] γ_1 = density of air in incident flow [kg/m³], γ_0 = density of air [kg/m³] at 20°C and normal atmospheric pressure, and ν =

kinematic viscosity of cooling air [m²/sec] ; α = mean heat-transfer coefficient for the periphery of the cylinder [kcal/m²hr°C] and λ_{air} = thermal conductivity of air = 0·0218 kcal/m hr°C.

The distribution of heat-transfer coefficients α and free-air flow velocities V around a cylinder of 118 mm diameter with relatively closely spaced fins, at different angular positions Φ relative to the incident flow, are shown in Fig. 3. With thicker, more widely spaced fins, somewhat lower values of α are obtained, but with a more constant distribution around the cylinder.

Curve (4) in Fig. 2 refers to a finned cylinder with a ducted flow (between semicircular baffles with faired passages at the entry and exit). In this case, the reference ratio R_2 is taken as

$$R_2 = \frac{V' \gamma_1 s^2}{\nu \gamma_0 D^{0.25}} \quad .. \quad .. \quad (4a)$$

where V' = flow velocity between the fins [m/sec]. The value of V' can be calculated by procedures indicated by Löhner[2] and Berndorfer[4], but it can also be obtained more simply from the curves in Fig. 4, in which the specific flow rate $V'\gamma_1$, is plotted as a function of the flow resistance $\Delta p \gamma_m / \gamma_0 L$, where γ_1 = density of the cooling air in the incident stream [kg/m³], Δp = assumed or measured value of the pressure drop [mm w.g.] during flow between the fins, γ_m = mean density of cooling air flowing through the fins [kg/m³], and L = mean length of the path between the fins [m]. Since γ_1 is known, V' can be determined directly from the corresponding value of s.

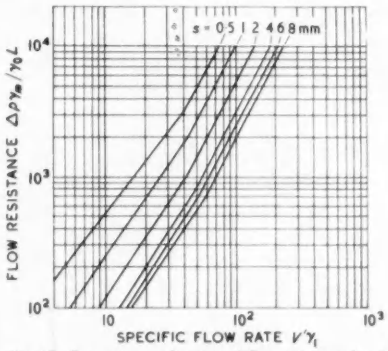


Fig. 4. **Specific flow rate as a function of flow resistance for different values of fin spacing s.**

Investigations have shown that V', as a function of $\Delta p/L$, depends almost exclusively on the free distance s between the fins. The value of V' is slightly dependent on the outside diameter D of the cylinder, and in no way dependent on the fin depth b and thickness t. The amount of heat extracted from a finned cylinder for various conditions of incident flow can be predicted from eq. (3) and Figs. 2 and 4, and the results agree with the values obtained by actual tests to within about 5%.

Optimum Fin Arrangement and Design

When the cooling effect ε is calculated from eq. (3) for constant values of fin depth b, fin thickness t, and incident flow velocity V, with different distances s between the fins, it is found that ε tends to decrease for very close or for very wide spacings of the fins, and that it reaches a maximum at some intermediate value. This is also found to be the case when s is kept constant and t is taken as the only variable. Thus, maximum heat extraction ε depends on a

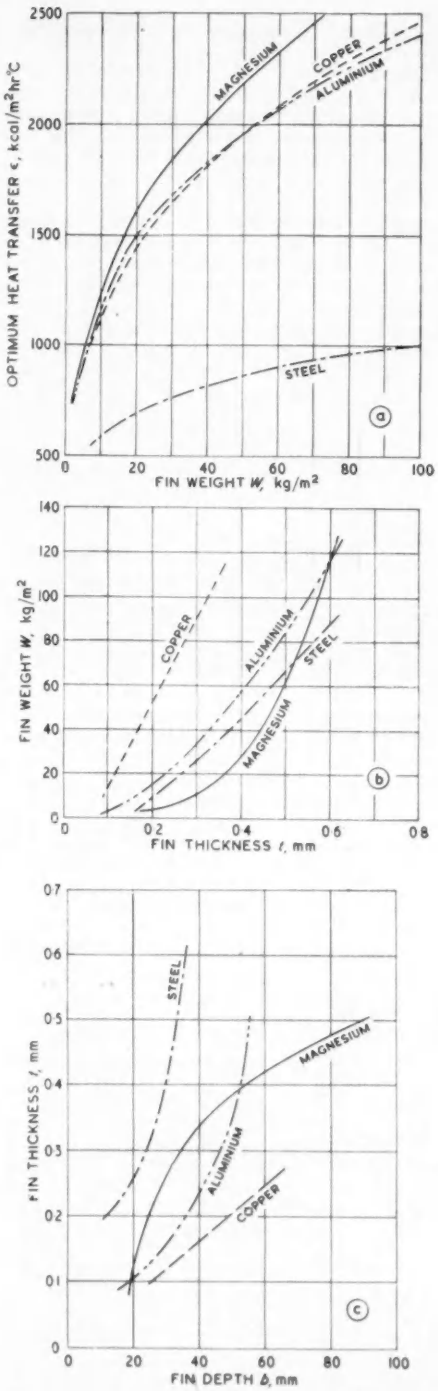


Fig. 5. **Curves for determination of the dimensions of fins of various materials for optimum heat transfer, assuming a pressure drop of 100 mm w.g. and a cylinder diameter of 118 mm.**

pair of values of s and t which in turn depend on the values of b and V and, to a slight extent, on the diameter D of the cylinder.

The simplest method of determining optimum fin parameters is by means of graphs which were first evaluated in the U.S.A.[3,5]. To reduce the number of evaluations, D can be kept constant, and for convenience has been taken as 118 mm. When these evaluations were initiated, the requirement was to find optimum values of ε for a specified weight per unit area W of the fins [kg/m²]. The corresponding curves for various materials, assuming a cylinder diameter D of 118 mm and a pressure drop Δp of 100 mm w.g., are given in Fig. 5, in which an overall value for W is taken for the desired value of ε from Fig. 5a, and the fin thickness t and depth b determined respectively from Figs. 5b and 5c. The value of the interspace s is determined from the relation between the weight per unit area of the fins and their dimensions, i.e.,

$$W = \frac{\gamma_F\, bt}{s+t}\left(1+\frac{b}{D}\right) \quad .. \quad .. \quad (5)$$

where γ_F = density of the fin material.

Nowadays, more importance is placed on having a compact engine of the smallest possible dimensions, rather than on minimum weight, and for this purpose it is convenient to specify preferably the fin depth b (which can be regarded as a constant in eq. (3)), and to determine the most favourable combination of values of s and t.

In the case of cylinders in free air flow, evaluations for minimum weight or depth are hardly worth while, since in all cases where high amounts of heat transfer are required, ducted flow arrangements are to be preferred. Moreover, the optimum value could be calculated fairly easily by using various trial values in eq. (3) for certain conditions. It may be noted, however, that maximum heat transfer for free air flow occurs with such small fin spacings and thicknesses that it is unlikely to be achieved in practice, if only because of manufacturing considerations.

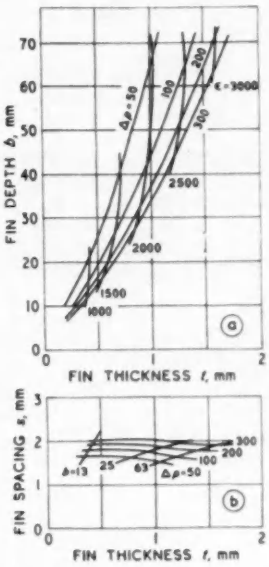
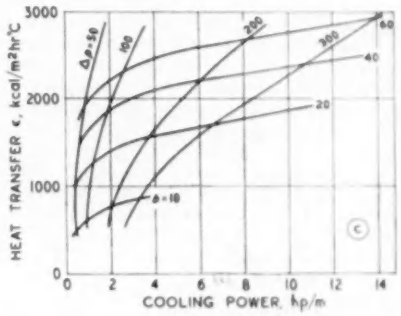


Fig. 7. Curves for determining combinations of fin spacing and thickness and cooling power required for optimum heat transfer, with a specified fin depth, for aluminium fins on a cylinder of 118 mm diameter.



In the case of ducted cylinders, when considering optimum heat transfer for minimum fin weight, the relation between the weight of the fins and their dimensions has already been given in eq. (5), and the evaluation procedure has been described in conjunction with Fig. 5. Steel fins are, of course, far less favourable than magnesium, aluminium, or copper fins when minimum weight is required, but, from the point of view of fin dimensions, copper is superior to the other materials. Thus, for instance, from Fig. 5, for a value of ε of 1800 kcal/m²hr°C and a weight W of 40 kg/m², the dimensions of an aluminium fin are thickness t = 0·36 mm and depth b = 50 mm, as against t = 0·17 mm and b = 40 mm for a copper fin.

To determine the most favourable combination of fin spacing s and thickness t for a given depth b, Figs. 6 and 7 have been prepared. Thus, for steel fins, the values of ε and t for an estimated range of pressure drop Δp and specified depth b can be taken from Fig. 6a. Fig. 6b then gives the fin spacing s, while corresponding values of horsepower dissipated per metre of cylinder height are given in Fig. 6c. A similar procedure is used with Fig. 7 for aluminium fins.

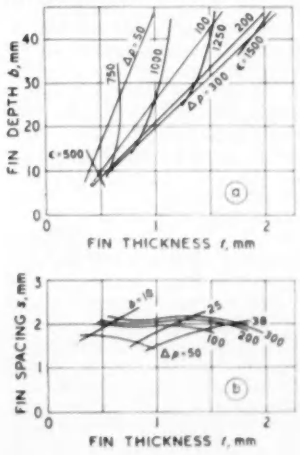
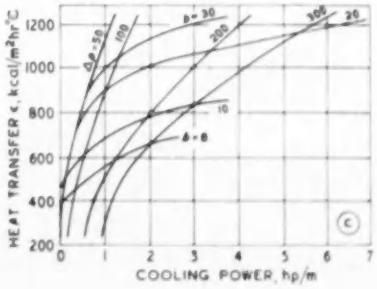


Fig. 6. Curves for determining combinations of fin spacing and thickness and cooling power required for optimum heat transfer, with a specified fin depth, for steel fins on a cylinder of 118 mm diameter.



It will be seen that, for a pressure drop Δp through the fins of 100 mm w.g., and a fin depth b of 30 mm, maximum heat dissipation is obtained with a fin spacing s of 1·9 mm and a thickness t of 1·1 mm. These graphs can also be used to evolve new fin arrangements, with pre-specified values of b and Δp. However, the corresponding fins will generally

be found to be too thin for mass production. If the thickness of the fin is made somewhat greater than that indicated in the graphs, the spacing s will also have to be increased, and the most suitable solution is obtained by several trial evaluations.

As mentioned, Figs. 6 and 7 are intended for use with steel and aluminium fins only. Corresponding graphs for magnesium and copper have not been included, as they are rarely used, despite their low weight and high conductivity and the fact that for minimum depth the highest heat transfer is obtained with copper.

The cooling effect ε in Figs. 6c and 7c is related to the cooling power required per metre of cylinder height. From these curves, it can be seen that it is best to choose a value of pressure drop between 100 and 200 mm w.g. since, for fins of constant depth, values of Δp above 200 provide only a slight increase in the value of ε.

As an example of the use of these graphs, Fig. 7c shows that, for aluminium fins of depth $b = 20$ mm and a pressure drop Δp of 100 mm w.g., $\varepsilon = 1250$ kcal/m²hr°C and the required cooling power is about 1 hp/m, while the corresponding values of fin thickness t and spacing s (from Figs. 7a and 7b) are respectively 0·5 and 1·8 mm. If the value of ε is to be raised to 1750 kcal/m²hr°C and Δp is increased to 300 mm w.g., then, with $b = 20$ mm, the required power is about 7 hp/m, whereas, if Δp is kept at 100 mm w.g. and the depth b is increased to 38 mm (with corresponding values of t and s of 0·8 and 1·8 mm respectively), the required power is only about 1·6 hp with a value of ε of 1750 kcal/m²hr°C. It can thus be seen that it is always preferable to increase fin depth than pressure drop.

Improved Heat Transfer by Interrupted Fins and Baffles

To maintain low values of pressure drop and cooling power required, the length of the path along the finned sections should not be excessive. It has been verified by Löhner and by Helmbold[6] that a considerable increase in the mean heat-transfer coefficient can in fact be achieved by interrupting the fins at suitable points. The resulting " gap factor " is thus another quantity to be considered, in addition to fin spacing s and thickness t, and has a maximum value, since with subdivided fins the heat-transfer coefficient increases, whereas the heat-dissipating surface area becomes smaller. Additional tests would be required for a complete exploration of the effect of this third factor.

As already mentioned, the heat-transfer coefficient is very considerably affected by the use of baffles[7] providing ducted flow conditions (Fig. 2). In this connection, a " split-plate " baffle system developed by Berndorfer[8] is stated to reduce the power required for cooling, while still providing good heat dissipation.

Conclusion

The heat-transfer coefficient α of a finned cylinder wth optimum fin dimensions can be determined from eqs. (1) and (3) and the corresponding graphs. In eq. (1) there are two unknowns, i.e., the quantity of heat Q and the temperature difference ΔT, and one of these has to be assumed in order to evaluate the other.

Consequently, when a new finned cylinder design is being developed, either of two general approaches to the problem can be employed, i.e., (1) the quantity of heat Q to be transmitted by the gases in the cylinder to the cylinder walls can be specified[9], or (2) an existing cylinder, basically similar to the design under development, can be investigated, its cooling effect determined, and similar values assumed for corresponding positions in the new design.

The temperatures at the root of the fins can be estimated roughly by means of the heat-conduction equation and by assuming specified values of heat transmitted to the inner surfaces of the cylinder walls[9], the temperature of the cooling air flowing out of the fins being calculated from the assumed quantity of heat. An assessment of the accuracy of the assumed values is obtained by measuring fin and cooling-air temperatures on an existing cylinder.

REFERENCES

(1) E. Schmidt : " Die Wärmeübertragung von Kühlrippen " ; *Z.V.D.I.*, 1926.
(2) K. Löhner : " Leistungsaufwand zur Kühlung von Rippenzylindern bei geführtem Luftstrom ". Dissert., Berlin, 1933.
(3) A. E. Biermann and B. Pinkel : " Heat Transfer from Finned Metal Cylinders in an Air Stream " ; N.A.C.A. Report 488.
(4) H. Berndorfer : " Vorausberechnung des Kühlluftaufwandes " ; *M.T.Z.*, 1953, page 57.
(5) A. E. Biermann and H. Ellerbrock, Jr. : " The Design of Fins for Air-Cooled Cylinders " ; N.A.C.A. Report 726.
(6) Helmbold : " Entwicklungsarbeiten an luftgekühlten Zylindern " ; Jahrb. der deutschen Luftfahrtforschung, 1942.
(7) O. W. Schey and V. G. Rollin : " The effect of Baffles on the Temperature Distribution and Heat Transfer Coefficient of Finned Cylinders " ; N.A.C.A. Report 511, 1935.
(8) H. Berndorfer : " Spaltplattenverkleidung " ; Jahrb. der deutschen Luftfahrtforschung, 1942.
(9) K. Löhner : " Luftkühlung an Brennkraftmaschinen " ; *M.T.Z.*, 1944, page 15.

Possible New Methods of Rocket Propulsion

(*Concluded from page 95*)

exhaust nozzle. The centre portion and the reflectors can be rotated freely, so that the vehicle can accelerate in any direction with respect to the sun. Disadvantages of this design are the extremely lightweight construction necessary, with accompanying operational limitations.

Free Radicals

Representing one of the most concentrated forms of chemical energy, free radicals are still only poorly understood, although their existence has been known for nearly 60 years. The radical, a single atom or larger fragment of a molecule, is highly unstable and remains in a free state for only a few thousandths of a second, after which it recombines chemically, releasing considerable energy.

It has only recently been found possible to capture and store these molecular fragments for any length of time. One technique is to pass a gas such as hydrogen or nitrogen through a 2450-Mcs radio-frequency field to produce quantities of free radicals in a highly excited state, and then to lower their temperature to about —450°F before they have time to recombine. Frozen in this way, the free radicals remain in this state for several hours. When the molecular fragments recombine, much of the energy released is in the form of light, and the remainder as heat.

With regard to their use in rocket propulsion, there can be no doubt that free radicals will present difficult problems with regard to storage, handling, and the need for heat-resistant materials to withstand the very high temperatures involved. At the same time, however, it should be remembered that, whereas present fuels limit specific impulses to from 250 to 270 sec and the use of fluorine or other materials may increase the value to about 400 sec, free radicals may provide specific impulses starting at 500 sec and finally attaining as much as 1280 sec, if, as is the ultimate object, pure hydrogen can one day be used successfully.

Reduce your costs with

GOODYEAR

LONG LENGTH

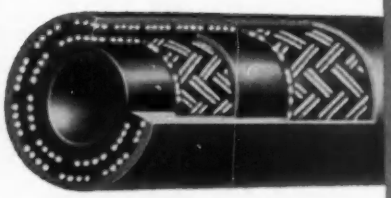
AIR HOSE

Whatever your air hose job, you can reduce your costs by using Goodyear Long Length Hose. It's your most economical buy—

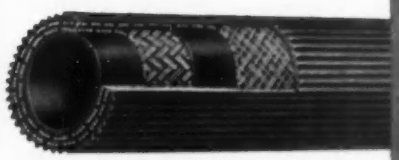
BECAUSE
it can be cut to any length up to 500 ft., so eliminating hose wastage.

BECAUSE
it needs fewer couplings. Cuts not only the initial expense of couplings but also cost of maintaining them.

BECAUSE
it lasts longer. Goodyear Long Length Hose has a non-porous tube and abrasion-resistant cover built of high grade compounds for maximum wear.
Light in weight and of balanced construction, Goodyear Long Length Air Hose is easy to handle and resists kinking. There are two types of this hose—Style A and Style B, both available with smooth or corrugated covers.



STYLE A *for service where oil mist may be present in the line, and where operating pressures up to 325 lbs. per sq. in. are used.*



STYLE B *for general, light and medium pneumatic tool service and working pressures up to 210 lbs. per sq. in.*

Full details of both types can be obtained from Industrial Rubber Products Dept., Goodyear, Wolverhampton. We will also be pleased to advise on any air hose problem you have.

Specify

GOODYEAR

INDUSTRIAL RUBBER PRODUCTS

HOSE · V-BELTS
CONVEYOR BELTING
TRANSMISSION BELTING
FENDERS

what, no nuts? . . .

Nuts to use nuts? Well, not exactly, but the fact that the Tapping Screw obviates the use of nuts is just one of its distinct advantages over the conventional Machine Screw. There's the saving in time to consider too. And cost. And there's no doubt whatever that the tapping screw makes for a better job all round. With its self-locating point the tapping screw forms its own thread thereby eliminating a separate and expensive tapping operation. Obviously it makes for easier assembly, is stronger, cheaper and faster. Safer too when the Phillips recessed head is specified, designed for power driving without damage to worker or job. You'll be well advised to change over to Tapping Screws. Nothing nuts about that !

Linread

LINREAD LTD. COX ST. BIRMINGHAM 3

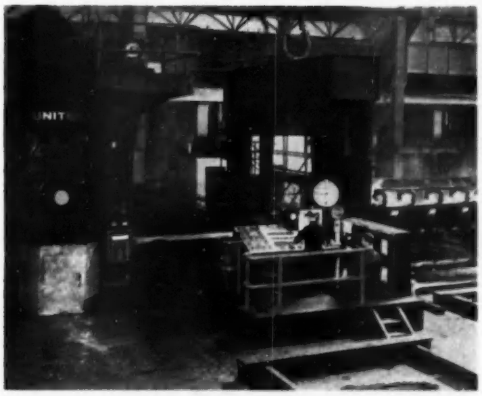
SLOTTED AND PHILLIPS RECESSED HEAD MACHINE SCREWS AND TAPPING SCREWS • HIGH TENSILE HEXAGON HEAD BOLTS AND SETSCREWS AIRCRAFT BOLTS, SCREWS AND RIVETS • SEMS • RIVNUTS • CUSTOM DESIGNED COLD FORGED FASTENERS • ALEX SCREWPLUGS.

British Industrial Developments

Infra-Red Width-Gauge for Continuous Hot Strip Mills

Developed from a system initiated by the British Iron and Steel Research Association, and relying on the natural radiation of infra-red rays from the hot strip, the Evershed width-gauge, supplied by Evershed and Vignoles Limited, of Chiswick, London, to the steel company of Wales, is a servo-driven optical arrangement for monitoring width in continuous hot strip mills.

With this gauging system, which is sufficiently sensitive to respond to material that has cooled to a very dull red, two edge followers are used, each of which tracks the individual motions of the edges, the combined readings being summated electrically to give a signal which is proportional to the deviation in total width. The edge followers are mounted on a traverse which straddles the mill a few feet above the run of strip, and are motorized, so that the two may be spaced apart to a distance equal to the nominal width of strip being produced.



The method of detecting and tracing the change in edge position reduces to a minimum any variations that may arise in signal strength due to fluctuations in the rolling temperature. Radiation from the surface of the strip is projected through a lens and prism onto two photocells, placed side by side, one of which receives a constant amount of energy from a section of strip inboard of the edge, whilst the other is activated by the edge itself. Movement of the edge increases or decreases the radiation on this cell, depending on the direction in which the strip moves. A shutter is driven across the face of the other photocell, reducing the energy on it to a value equal to that obtained by its neighbour. This system of balancing radiation ensures freedom from temperature effects and compensates for changes in the cell characteristic caused by ageing. Each follower is self-contained, inasmuch as it consists of an optical and photo-electric sensing device which presents a "chopped" signal to a built-in 50-cps amplifier, the output of which drives the shutter mechanism by means of a small a.c. servo-motor.

If desired, a roll-chart recorder can be used in conjunction with the width-gauge, which is stated to have an accuracy of $\pm \frac{1}{16}$ in.

Sealing-Layer Process for Metal-Treatment Baths

A new process for eliminating fumes and steam from aqueous metal-treatment baths and for reducing heating costs has been introduced by the Paints Division of Imperial Chemical Industries Ltd., of London, S.W.1. Designated the "Serseal" layer process, it seals the surface of the processing liquid in the bath with a layer of inert material, not only checking fumes and steam but also reducing the amount of heat needed to keep the bath at a working temperature, so much so that it is reported that, under production conditions, savings in fuel of up to 75% have been recorded.

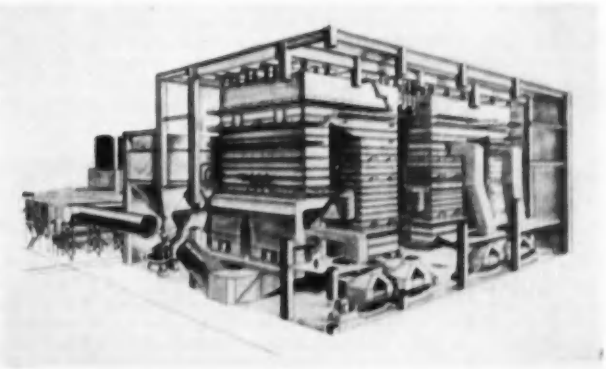
Because the use of "Serseal" eliminates steam and condensation, exhausting equipment can often be dispensed with. Working conditions are improved, and shop condensation and structural corrosion are retarded. Furthermore, the process can be operated without alteration to the processing tank, while an additional advantage is that, owing to the reduced heating requirements, heating units need much less frequent cleaning, and maintenance costs are reduced.

Although the new process was developed primarily for use in baths producing heavy phosphate coatings, such as those employed in the I.C.I. "Granodine 101" process, it has now been extended to other "Granodine" processes. Alternative grades of "Serseal" are available to suppress acid fumes and spray from pickling tanks and to conserve heat in alkaline paint-stripping vats.

550-MW Reheat Boiler Unit

The 550-MW power-station boiler designed by International Combustion Ltd., of London, W.C.1, for the Thorpe Marsh power station of the Central Electricity Generating Board will, it is believed, have a capacity greater than any single unit under project in the world. Designed to serve the requirements of a corresponding 550-MW turbo-alternator, which is also much larger than any now in operation, the boiler will have a guaranteed thermal efficiency of 90%, believed to be the highest yet envisaged by the Central Electricity Board, and this will be achieved despite the necessity of using low-grade coals of widely differing quality, with ash contents from 6 to 30% and moisture contents from 4 to 20%.

By comparison with a 60-MW boiler unit, which was the largest size installed in Great Britain ten years ago, the new 550-MW unit will occupy about half the space



A question of LIGHTNESS and STRENGTH?

ALDRIDGE have the answer!

It need not be heavy to be strong! Plastics mouldings can provide lightness with strength, and ALDRIDGE make all types of thermo-setting and thermo-plastic mouldings for the Electrical, Automobile and many other industries. ALDRIDGE manufacture to specification or, if required, design the whole job for you. So whether it's a question of lightness and strength, insulation, close tolerances or any other factor—you should consult ALDRIDGE.

General thickness of the moulded components of this new desk telephone case and handset is only 3/32" which ensures extreme *lightness*. The use of high-impact polystrene, the subtle curves and clever design provide the necessary *strength* for years of trouble-free use.

ALDRIDGE for PLASTICS mouldings

ALDRIDGE PLASTICS LTD.

REDHOUSE INDUSTRIAL ESTATE, ALDRIDGE, STAFFS.

TELEPHONE: ALDRIDGE 52031 (4 LINES)

SALES OFFICE: 155, CHARING CROSS ROAD, W.C.2. GERrard 4820 & 8660.

A.I.D. APPROVED. CONTRACTORS TO H.M. GOVERNMENT DEPARTMENTS.

An A.E.I. Company

L.G.B.

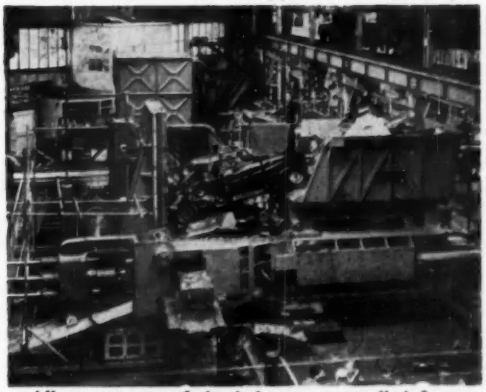
required for a series of 60-MW units with a comparable aggregate capacity. Furthermore, by incorporating the latest design features, including assisted circulation, improved combustion-chamber design, and pulverizers of increased capacity, the capital cost will be about 65% of that involved with the smaller units.

Operating conditions involve a steam pressure of 2400 psi, steam and reheat-steam temperatures of 1055°F, a feed pressure of 2600 psi, a feed temperature of 496°F, and an evaporation rate of 3,750,000 lb/hr. Two furnaces per boiler will be provided, 68 ft wide × 28 ft deep × 100 ft high, each subdivided, one furnace being arranged for superheat steam temperature control, and the other for reheat temperature control.

Triple-Compression Scrap-Metal Baling Press

A new triple-compression hydraulic press, designed for Colvilles Limited for the baling of heavy-grade scrap-metal, has now been completed by Fielding & Platt Limited, of Gloucester. The new press, which is completely self-contained and incorporates its own high-pressure pump system, supply tank, control valves, and hydraulically operated 300-cu ft hopper, can handle up to approximately 20 tons of scrap per hour.

The scrap for baling is compressed in three stages, initial compression being applied over the whole of the baler-box area by a massive hinged cover applying a load of 270 tons. Secondary compression (360 tons) is brought about by the three rams and attached thrust-face moving along the box axis inside the closed box. Final compression is carried out by a single ram, operating at right angles to the secondary and applying a load of 480 tons. On completion of the operation the ejection door is opened and the final pressing ram ejects the bale, which weighs approximately 1 ton, onto the pusher-gear outside the baler box. Special steel cutting jaws are fitted to the baler-box door to shear through overhanging scrap. The cutters are renewable and can be removed for sharpening, when necessary. The hydraulic medium is supplied by a battery of Fielding totally enclosed reciprocating pumps, the maximum hydraulic working pressure being 3000 psi.



All movements of the baler are controlled from a console-type desk, the selection of operating conditions being made by a handwheel selector. Indicator lamps and pressure gauges on the panel keep the operator fully informed of the motions of the press. Control valves are of the mitre-seat, thrustor-operated type, and by-pass valves fitted in the hydraulic circuit allow the pump motors to commence operating under no-load conditions. To prevent the press being operated out of cycle, electrical interlocks are incorporated.

Some idea of the size of this installation can be gained from the illustration, which shows the press in the course of loading with scrap, including a complete car body.

High-Speed Rock Drill and Pusher Leg

Basically intended for operation with a new pusher leg, type BMT 50, the new " Lion ", type BBC22 WK, rock drill introduced by Atlas Copco (Great Britain) Limited, of Wembley, is designed for use in large tunnels or mines where holes from 10 to 90 ft are to be drilled, and is eminently suitable for operation with abrasive rock.

Weighing 66 lb and with a capacity 30% greater than that of any other machine of the same weight, it is claimed to be one of the fastest machines of its weight ever produced. The normal working air pressure is 85 psi, but the machine can easily be modified for use at 60 psi. Operating with a 43-mm bit and using a pressure of 85 psi, the drilling speed is about 2 fpm in hard granite, 3 fpm in sandstone, and 4 to 5 fpm in shale, the drill delivering 2000 blows per minute and 200 rpm, with an air consumption of 152 cfm.

All the necessary controls have been concentrated on the back-head and handle, so that it is possible to start feeding, then flushing, and finally drilling with the same throttle lever. The feed pressure of the pusher is adjusted by a second back-head lever. From the back-head the air is fed through channels to the cylinder and the pusher, so that an air hose for the pusher is redundant. A new type of patented double-opening direct flow valve is provided, and the rotation mechanism incorporates a rifle-bar opening with four pawls. Standard rotation is on the return stroke. Particular attention has been paid to ensure adequate lubrication of the front head of the drill.

The drill is flushed through a large-size concentric axial tube, the water being controlled by a valve interconnected with the throttle. There are two cylindrical handles on the back-head ; the initial feed, the flushing water, the striking mechanism of the drill, and extra blowing are controlled by means of the handle on the right, while the handle on the left regulates the feed pressure.

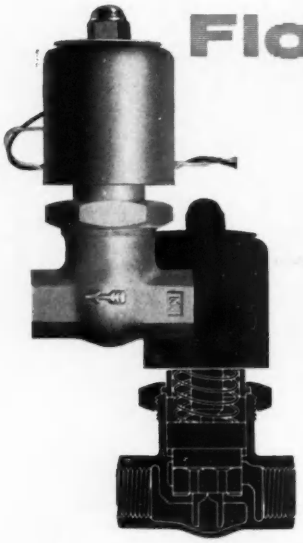
The retraction of the piston rod in the pusher is carried out by means of compressed air. To retract the leg the operator merely depresses the valve in the handle, thus saving time and increasing the gross drilling speed. This valve is also used as a release valve for pusher feed for variation of the thrust required during drilling. The cylinder of the pusher leg is connected to the cylinder of the rock drill, thereby ensuring that drill dust and other foreign matter cannot enter the pusher-leg cylinder.

Composite Sintered Hard-Alloy and Steel Components

The latest development announced by Danite Hard Metals Limited, of Carr Hill, Doncaster, is the production of composite " Danelle " and steel components. By combining Danelle, which covers a range of wear-resistant hard alloys, with steel in this way, it is now possible to

BIRFLO controls

for positive and precise regulation of water, light oils or air flow



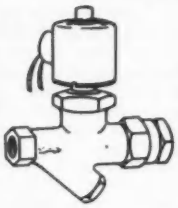
Flomax

VALVE

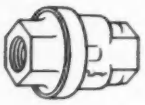
positive control of flow pressures up to 150 p.s.i.

The "Flomax" is a two way normally closed solenoid valve for various fluids, specially designed for maximum flow capacity. It is suited to industrial applications where long life and trouble free operation is a necessity. The "Flomax" provides maximum flow at minimum cost. It is self-closing, quick acting, packless, anti-hammer, and quiet in operation. Readily adapted to direct switch operation, automatic or remote control, or time cycle operation and designed for continuous duty operation, the "Flomax" represents a considerable advance—both in design and working efficiency—in the field of solenoid valves.

The "Flomax" is one of seven Birflo controls, each one designed to overcome a particular flow problem.

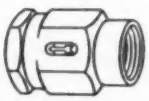


FLOMETRIC
A compact assembly of solenoid valve, flow rate control and inlet strainer. Rated up to 5 g.p.m.

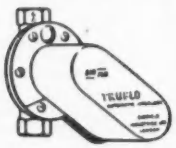


MULTI CONSTAFLO
An accurate metering valve for flow rates up to 18 g.p.m. Sizes ½" and 1"

FLOMITE
A direct acting solenoid valve for small flow and volume control. Sizes ¼" and ⅜"



CONSTAFLO
A consistent control for flow rates up to 8 g.p.m. Sizes up to ½".



TRUFLO
For positive flow-rate control with minimum 1/10 g.p.m. or maximum 40 g.p.m. limits.

STRAITFLO
A straight line strainer, installed in the supply, having the entire strainer area within the flow way itself. Sizes up to 1¼".

Made under licence from the Hays Manufacturing Co., Erie, Pennsylvania, U.S.A.

Fully informative leaflets on all the Birflo Controls are available on request.

product of **BIRFIELD** **GROUP** experience and resources

Enquiries to: **BIRFIELD INDUSTRIES LIMITED** · STRATFORD HOUSE · LONDON W.1

fill the need for parts in which selected portions or surface areas have good wear-resistant characteristics, while the remainder of the body is easily machinable.

Sintering of the materials of the component is simultaneous, and dimensional control is such that only small machining allowances are required. The Danelle portions have a Rockwell hardness of 56 and can therefore be machined only by grinding, while the softer steel portion has a tensile strength of 29 tsi and a yield point of 18 tsi. The Danelle alloys are not claimed to be stainless, but they have good corrosion resistance to nearly all fluids, with the exception of the strong mineral acids. Furthermore, although basically hard, they respond slightly to oil-hardening, but cannot be softened or annealed—a desirable feature, because their wear-resistant properties cannot be harmed by overheating. Insofar as the steel portion of the component is concerned, a carbon steel is normally used but, where corrosion resistance is required, components with stainless-steel bodies can also be supplied.

At present, the process is limited to the production of reasonable geometrical shapes and to maximum dimensions of roughly 4 × 4 × 4 in., these limitations being imposed only by the capacity of existing equipment and in no way representing the limitations of the process itself.

Special Machine for Lapping, Grinding-in, and Reconditioning Large Cocks and Valves

A special machine designed for the lapping, grinding-in, and reconditioning of large cocks and valves has been supplied by the Rockwell Machine Tool Co. Ltd., of London, N.W.2, to the Esso Petroleum Co. Ltd.

With this machine, which is of fabricated construction, the lapping compound is delivered to the component by means of a special pump, so as to ensure correct distribution and an uninterrupted flow. The cock housing itself is rigidly held on the machine table and, during the machine cycle, the taper plug, which is held in a special floating mandrel fitted to the machine spindle, is automatically lowered into the working position, where it is spring-loaded against its housing. As soon as the taper plug has reached this position, the mandrel holding the taper plug commences an alternate clockwise and overlapping anti-clockwise movement, i.e., the machine simulates the type of movement employed when hand-lapping small cocks and valves. An automatic timing device is preset to correspond with the time taken to grind in the cock, and a signal from this unit automatically stops the machine at the end of the cycle. It is stated that the time saved by using this machine for the lapping of large cocks, compared with conventional methods, is very considerable.

Graphite Bursting Discs

A range of bursting-disc assemblies in carbon and graphite, completely resistant to the corrosive effects of a wide range of contact materials and temperatures up to 160°C, without deterioration of physical properties or a reduction in bursting accuracy, has been introduced for the first time in the U.K. by Powell Duffryn Carbon Products, of Hayes, Middlesex. The assembly comprises a two-part carbon holder and a high-quality replaceable graphite disc. The design of the holder and disc is such that replacement discs are easy to install and, in addition, location of the disc in the holder is fool-proofed by means of a special slotted holder arrangement. The assembly clamps between pipework flanges adjacent to the installation to be protected.

The standard range is available in bore sizes of 2, 3, 4, and 6 in. Pressure ratings are between 5 and 75 psig, and bursting accuracy is guaranteed to within ± 5% of the rated bursting pressure. For discs rated at 20 psig or below, vacuum supports of either bar or dial type are available, if the possibility of vacuum conditions within the vessel exists. Working pressures may be up to 75% of the nominal burst rating. Special ratings are also available.

High-Precision Paper Guillotines with Mechanical Automatic Spacing

Stated to provide all the speed and accuracy of electronic spacing, without its cost and complexity, the new range of " Super-Como " paper guillotines, with cutting widths of 36¼, 46, or 52 in., made in Sweden by Como Maskin Ab, but utilizing British-built electromagnetic clutches and hydraulic pumps, is now being marketed in the U.K. by Gordon & Gotch Limited, of London, E.C.4.

The main feature of the new range of guillotines is that, instead of using an electronic spacing mechanism, as in many other well-known machines, a purely mechanical system is employed, in which a series of hardened metal stops, mounted on a bar, contacts another moving stop which works in conjunction with the back-fence. The setting of these stops, down to the minimum spacing distance of 1/64 in., is simple and precise, an accuracy of from 0·003 to 0·004 in. being claimed. Four separate bars, mounted on a common axis, enable four different cutting programmes to be obtained at any one time, each being brought into action by turning a handwheel. Any fine adjustment necessary to allow for variation in the lay edge of the stock can be made by means of a micrometer control. In the case of the 36-in. machine, this mechanism is actuated by pressing a button after each cut, whereas, in the two larger sizes, the stock can be brought forward automatically after each cut, though in all models the actual cutting stroke must be made by the operator.

The knife beam is pulled down from both sides and has a swing action. Removal of the knife and adjustment for wear can be effected quickly and precisely, and two special handles are provided for making this routine operation easy and safe. The clamp is of the interlocking type, and is pulled down from both sides. Without the clamp-plate in position the minimum cut is ⅞ in. Pressure,

AGRICULTURE

AUTOMOTIVE INDUSTRIES

EARTH MOVING • MACHINE TOOLS

MECHANICAL HANDLING

MARINE ENGINEERING • GAS INDUSTRY

WHATEVER THE JOB

THERE'S A

DUNLOP

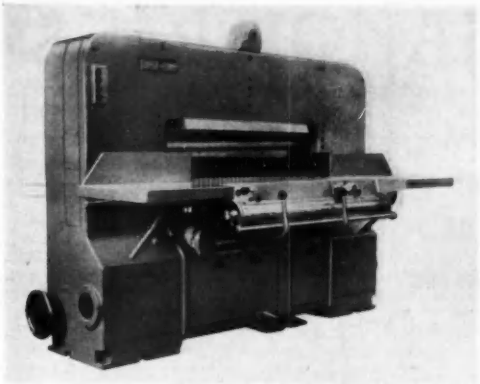
FLEXIBLE PIPE

TO CARRY IT THROUGH

Dunlop Technicians will always advise on any problems concerning installation of Flexible Pipes. Write please to :—

DUNLOP RUBBER COMPANY LIMITED · ST. GEORGE'S ROAD · COVENTRY · TELEPHONE: COVENTRY 64171

AM/902



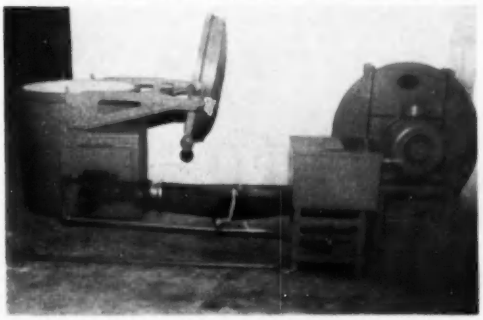
applied through a hydraulic unit, is infinitely variable up to 7000 lb and is indicated on a dial at the front of the machine. A foot-pedal at the front of the machine, power-driven to reduce fatigue, operates the clamp for manual setting. The hydraulic clamp is designed so that maximum pressure is gradually built up during the time it first comes into contact with the pile and before the knife starts to cut the paper. This system provides the clamp with a pressing action which prevents any sudden trapping of air within the pile or any movement of the sheets. The back-fence is of the divided/interlocking type and is fitted with a positive mechanical stop, so that work can be jogged against it without disturbing the setting. Overrun at either end is impossible, owing to the fitting of a slipping clutch in its drive.

The possibility of offcuts being pushed into the mechanism by the action of the knife has been overcome by the provision of a sliding plate which is pushed down simultaneously with the knife. A push-away guard is also supplied but, for further protection, a two-hand start is fitted. Extended side tables, integral with the front table, afford plenty of space for the operator, while the back table can be adjusted for angle of tilt. Optional extras include an air lift to the main and front tables.

Oil-Fired Crucible Furnace

The oil-fired crucible furnace introduced by Norris Equipment & Construction Ltd., of Bristol, is completely self-contained and requires no installation work, other than coupling up to electrical power and fuel-oil supplies. The standard unit, as shown in the illustration, comprises a refractory firebrick-lined furnace with oil burner, a motor-driven secondary-air fan with starter, 8 ft of oil pipe and flexible air hose for connecting the burner and the fan, and a 2-gal constant-level tank fitted with a ball-valve and stop-tap.

The furnace has a copper melting capacity of 150 to 200 lb, and will melt a charge of 150 lb of gunmetal from



cold in 50 min, the second-heat melting time for the same charge being 25 min. With a 200-lb charge, these melting times are 60 and 30 min respectively. Oil consumption is 3·5 gal/hr. The furnace casing is cast in one piece with walls of $\frac{3}{4}$ in. thickness and is lined with pre-cast sectional refractory firebricks designed to ensure that relining can be carried out by relatively unskilled labour. The lid of the furnace is conveniently carried on four rollers and is so designed that it will pivot to expose its underside, enabling repairs of the firebrick lining to be quickly effected.

The burner is of the low-air-pressure type and is designed to be easily dismantled without disturbing any pipe joints. By unscrewing a withdrawal nut, the whole inner assembly is forced out, leaving the body in position with the oil and air pipes still attached to it. There are no moving parts in the oil burner to wear or get out of adjustment, so that maintenance work is kept to a minimum.

Mechanical Splices for Wire-Rope Slings

Stated to overcome the drawbacks of other mechanical splices, the "Superloop" mechanical wire-rope splice, developed by British Ropes Ltd., of Doncaster, makes use of a new type of steel sleeve closed over the tails of a Flemish-eye splice. At present available in a range covering wire-rope diameters from $\frac{5}{16}$ to $1\frac{1}{4}$ in., the "Superloop" splice is said to be lighter, slimmer, and much easier to handle than other types of mechanical splice, while the special tapered tail of the sleeve and its small dimensions enable the splice to be employed in many applications where more bulky mechanical splices are impracticable. Furthermore, the splice is concentric with the rope, because of the Flemish eye incorporated, and this method of forming a loop develops a strength well in excess of the safe working load, even before the sleeve is fitted.

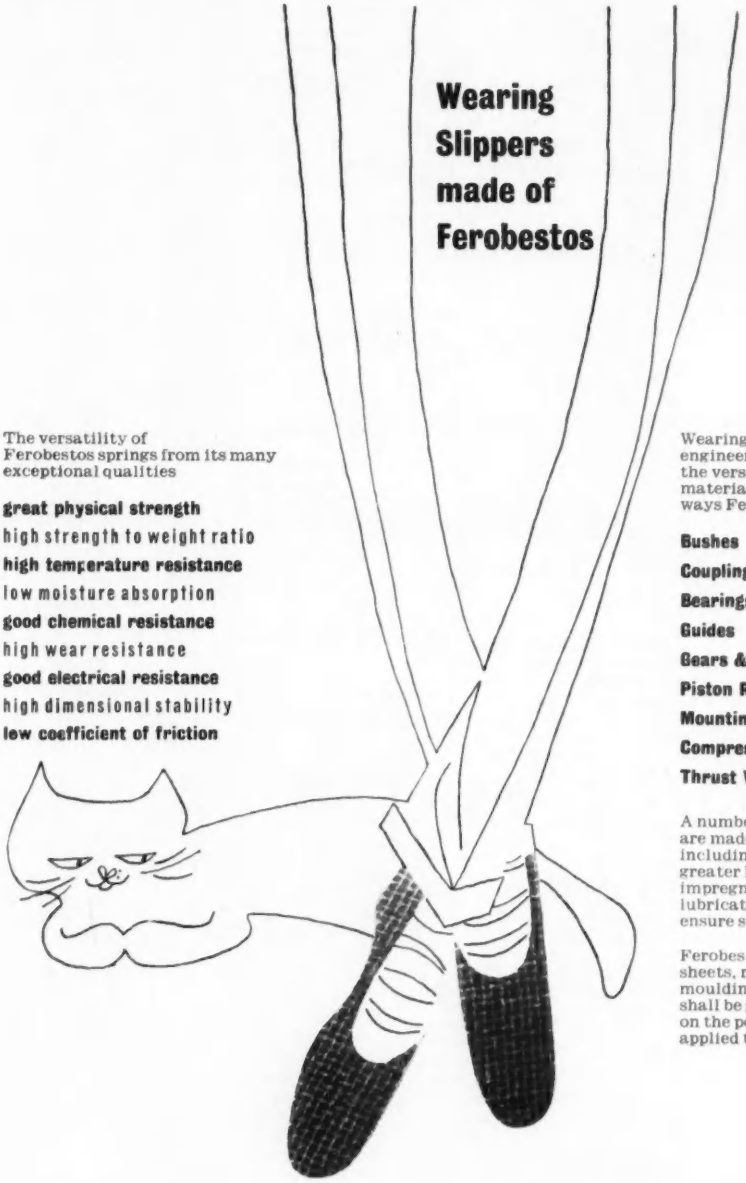
A specially developed stirrup, as shown in the illustration, is available to protect the bearing of the eye from wear, if required. Made from white-heart malleable iron in a wide range of sizes, the stirrup is fitted after the splice has been formed, but before the proof loading operation. Giving improved sling life and providing all the advantages of a thimble, while still retaining the flexibility of a soft eye, these stirrups can easily be replaced on the spot, in the event of damage.

While most standard six-stranded ropes can be successfully spliced with the new method, it is, however, basically intended for use with "Blue Strand" preformed wire rope, also produced by British Ropes Ltd. The wires in this rope are preformed into the exact helical position they take in the finished rope, so that, even when the rope is cut, the ends remain relaxed in their natural unforced position.

ERRATUM

In connection with the all-weather, non-deteriorating cement described on page 81 of our issue for February 1958, "Pentacrete" should have read "Pectacrete"

Wearing Slippers made of Ferobestos



The versatility of Ferobestos springs from its many exceptional qualities

great physical strength
high strength to weight ratio
high temperature resistance
low moisture absorption
good chemical resistance
high wear resistance
good electrical resistance
high dimensional stability
low coefficient of friction

Wearing slippers is only one of the engineering applications of Ferobestos—the versatile, asbestos-reinforced plastic material. Here are just a few more of the ways Ferobestos can be used:—

Bushes
Coupling Discs
Bearings
Guides
Gears & Rollers
Piston Rings
Mounting Pads
Compressor Blades
Thrust Washers

A number of special grades of Ferobestos are made for particular applications including silicone impregnated for greater heat resistance, and graphite impregnated for more efficient lubrication. Ferobestos gear wheels ensure silence in operation.

Ferobestos can be supplied from stock in sheets, rods, and tubes. Special mouldings can be made to order. We shall be glad to recommend and advise on the possibilities of Ferobestos as applied to any particular industry.

J.W. ROBERTS LTD

FEROBESTOS DEPARTMENT

Chorley New Road, Lostock, BOLTON. Tel: Horwich 840 *Branch Sales Offices: LONDON, GLASGOW, BIRMINGHAM, LEEDS.*

A Member of the Turner & Newall Organisation

ADDITIONAL ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

The Nature of Strain-Age Embrittlement.

By C. J. OSBORN. (From *Journal of The Iron and Steel Institute, London*, Vol. 188, Part 2, February 1958, pp. 97–101, 6 illustrations.)

THE notch-brittleness of mild steels has been demonstrated and investigated with a variety of physical tests, using a number of different criteria of brittleness. The results show that mild steels exhibit a sudden, severe embrittlement, with decreasing temperature over a narrow transition-temperature range, which is usually somewhere between ± 100°C, but which depends on both the test and the criterion of brittleness used. Furthermore, the transition range of a material measured by any particular test is known to vary appreciably with chemical composition and with its thermal and mechanical history.

Several investigators have distinguished between strain-age embrittlement and the strain-age hardening which produces changes in hardness, yield behaviour, electrical properties, etc. Since most investigations, including the theoretical treatments by Cottrell and his collaborators, have dealt primarily with strain-age hardening, any study of strain-age embrittlement must begin with a critical examination of the distinction drawn between these two aspects of strain ageing. If the distinction is real, there is urgent need for a thorough investigation of the embrittlement phenomenon. If, on the other hand, both processes are simply different manifestations of the same structural changes, an immense volume of data on strain-age hardening becomes significant in the study of strain-age embrittlement. This paper presents some evidence that this is actually the case.

The embrittlement which occurs in steel during ageing after plastic deformation can be studied conveniently by means of a notched-bar test, provided that the conditions of this test are carefully chosen and controlled. Curves showing the progress of embrittlement with time of ageing of a low-carbon iron at 30° and 80°C closely resemble the corresponding strain-age hardening curves, and it is suggested that both embrittlement and hardening are due to the same basic process. It is shown that this proposal is not incompatible with the experimental results published by previous workers. The activation energy for strain-age embrittlement is calculated to be of the order of 20,000 cal/mole, i.e., the same as for strain-age hardening.

The Role of Interfacial Energy during Solid-State Phase Transformations.

By M. HILLERT. (From *Jernkontorets Annaler, Sweden*, Vol. 141, No. 11, 1957, pp. 757–789, 11 illustrations.)

THE role of interfacial energy during the grain-growth process and during the very first stage of phase transformations (the so-called nucleation process) has long been recognized, and many quantitative treatments have been published on this subject. On the other hand, the effect of interfacial energy on the kinetics of phase transformations has been largely neglected. The present paper is limited to binary systems and deals mainly with solid-state transformations. The effect of interfacial energy on the composition of two crystals separated by a curved interface is considered, and the derived equations are first applied to nucleation and grain growth. The main portion of the paper, however, deals with the growth of a new phase and of an aggregate of two new phases from a parent phase. Special attention is paid to the isothermal transformation of austenite and the nature of bainite.

As described in this paper, the interfacial energy of a curved interface changes the compositions and activities of the two phases. These changes are calculated and the equations derived are applied to different processes. In addition, the driving force for grain growth in a single-phase alloy is calculated, and it is demonstrated how the composition and size of a critical nucleus can be evaluated directly from a free-energy diagram, and also how the composition of the new phase changes as it grows.

The diffusion-controlled growth of a new phase in a supersaturated matrix is considered, and it is shown how a growing crystal develops into a plate or needle, growing with constant speed and shape. Equations are derived for these quantities by two methods, one based on dimensional arguments, the other on the two and three-dimensional diffusion equation.

The diffusion-controlled growth of two new phases is also considered, and the shape of the interface between growing pearlite and austenite is determined. Calculated values of the growth rate and interlamellar spacing are essentially in agreement with earlier calculations. Some approximations are examined, in order to explain the discrepancy between calculated and measured data.

The theoretical growth rate of a single phase and of two phases in co-operation are compared, and it is found that a single phase has the highest growth rate, if its interfacial energy is low enough. The nature of bainite formation is thus explained in terms of the interfacial energy. The existence of a bainitic structure is postulated, where cementite is the leading phase, together with some experimental evidence of this inverse bainite.

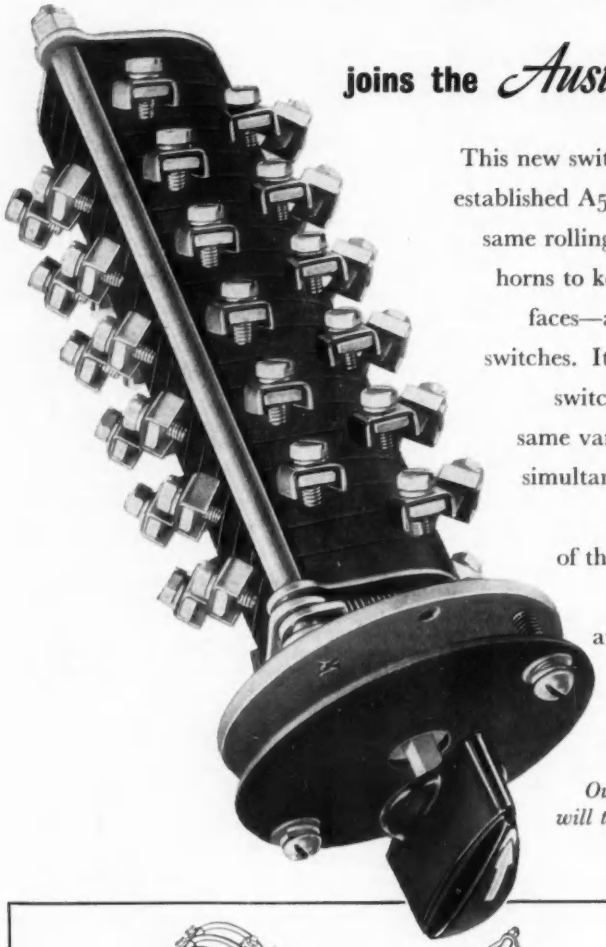
Electro-Mechanical and Electro-Acoustical Analogies.

By B. GEHLSHOJ. (From *Acta Polytechnica, Sweden*, Electrical Engineering Series, Vol. 8, No. 1, 1957, 143 pages, 81 illustrations.)

IN the early days of electricity, attempts were made to enlarge the understanding of alternating currents by comparing them to mechanical vibrations. Soon, however, new and simple methods of computing electrotechnical problems were developed and are now used by all electrical engineers, while the mechanical vibration theory is mastered only by a rather limited number of specialists availing themselves of rather complicated methods. Telecommunication engineers have often felt the lack of uniform methods for computing electrical and mechanical oscillations, and this has resulted in a number of attempts at using electrical diagrams and computing methods when dealing with mechanical systems. In this work the writer demonstrates the possibility of dealing with mechanical and acoustical problems in a manner which in many respects is analogous with the well-known method of dealing with electrical circuits.

In this monograph is presented a survey of the principles and applications of the electrical circuit analogies of mechanical and acoustical oscillating systems. The subject matter is divided into three parts, covering mechanical systems, acoustical systems, and electro-mechanical transducers. In the first part, complex mechanical impedance and admittance (mobility) are introduced, and it is shown that analogy between mathematical expressions for electrical and mechanical systems leads to two different types of mechanical diagrams, for which impedance and admittance diagrams are used. The admittance diagram proves to be the more natural, as it represents a simplified picture of the mechanical system, and it is, in fact, possible to draw this diagram by inspection, without recourse to any electrical analogy of mathematical expressions. Kirchhoff's laws are applied to mechanical systems, and examples of the composition of mechanical diagrams are given, including

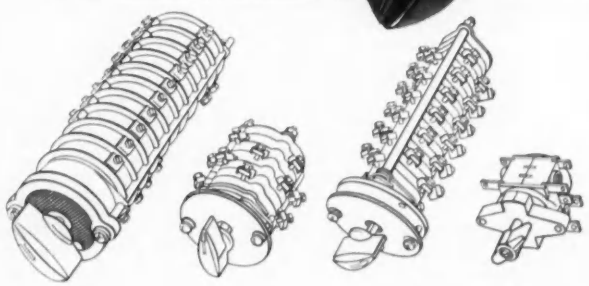
Now the A15—



joins the *Austinlite* rotary switches

This new switch is identical in principle to the well established A50 and A30 rotary switches. It has the same rolling, self-cleaning contacts with extended horns to keep any arcing away from the contact faces—a feature exclusive to Austinlite rotary switches. It has a similarly powerful and positive switch mechanism, and can be built in the same variety of forms to switch in sequence or simultaneously very large numbers of circuits. It is extremely compact, the smallest of the Austinlite multi-cell rotary switches. It bridges the gap between the A30 and the little single-cell 10-amp switch. Delivery, on standard applications, can now be made in four weeks.

Our brochure "SIMPLIFIED SWITCHING" will tell you more about the advantages of Austinlite Rotary Switches. May we send you a copy?



The four Austinlite Rotary Switches—A50, A30, A15 and A10

Austinlite

ROTARY SWITCHES

tailor-made by

STONE-CHANCE LTD.

(Makers of Sumo Pumps and Stone-Chance lighthouses). Crawley, Sussex

levers, mechanical filters, and gramophone pick-ups. Mechanical impedances are derived for systems with lumped and with distributed constants, e.g., vibrating rods and springs. The reciprocity between admittance and impedance diagrams is investigated, and it is shown how one type of diagram may be derived by inversion of the other. The possibilities and limitations of the analogies are discussed.

In the second part, electrical analogy is applied to acoustical systems. Kirchhoff's laws are introduced, and some impedances are given or calculated. The composition of acoustical diagrams is shown in examples comprising acoustical filters and the acoustical parts of microphones and telephones.

The third part deals with electro-mechanical transducers, which fall into two categories, i.e., the electromagnetic type, in which an admittance diagram of the mechanical side can be considered to be part of the electrical circuit, and the electrostatic type, in which in a similar way an impedance diagram of the mechanical side can be used. Examples are given of transducers of moving-coil, moving-armature, condenser, and piezo-electric types.

Glands for the Entry of Electrical Cables into Pressure Vessels Containing or Surrounded by Conducting Liquids.

By H. H. GRUNWALD. (From a paper presented at a meeting of *The Institution of Mechanical Engineers, London*, February 21, 1958, 12 pages, 12 illustrations.)

IT is often required to house electrical apparatus in pressure vessels capable of withstanding considerable pressure, either external or internal, and to make connection with such apparatus. For this purpose, electrical cables containing one or more insulated conductors must be passed through the walls of the vessel. This paper is concerned with the theory, design, and construction of seals through which one or more electrical conductors pass into vessels containing or surrounded by non-insulating liquids under pressure. Such seals, which are referred to as cable-entry glands, have many uses in various branches of modern engineering, such as shipbuilding, atomic energy and chemical engineering, etc. In telecommunications engineering, in particular, cable-entry glands have assumed great importance with the development of submerged repeater devices inserted in submarine cables to boost the signal currents employed in long-distance telephone and telegraph systems.

The paper states the fundamental requirements of cable-entry glands and gives a summary of the principles of construction employed. Experimental work is described which led to the development of two designs of gland. The first of these was developed specifically for the entry of submarine telecommunication cables into submerged repeaters containing electronic amplifying equipment, in particular those used on the British section of the first transatlantic telephone cable system. Both the manufacture and testing of these glands are reviewed. The second design dealt with is a simplification of the first, based on the experience gained. In addition, some special operating conditions encountered are mentioned, and the means of meeting the resulting additional requirements are discussed.

Evaluation of Stresses in a Pressure Vessel with Circumferential Ring Stiffeners.

By F. W. CATUDAL and R. W. SCHNEIDER. (From *The Welding Journal, U.S.A.*, Vol. 36, No. 12, December 1957, pp. 550s–552s, 4 illustrations.)

CYLINDRICAL pressure vessels operating under external pressure are frequently strengthened against collapse by means of circumferential stiffening rings welded to the shell. A shell can be stabilized against collapse by making the wall sufficiently heavy ; however, in many instances it is more economical to use a thinner shell strengthened by means of circumferential ring stiffeners.

Many vessels which normally operate under external pressure conditions may, at times, operate with positive pressure in the shell. It is thus the purpose of this paper to evaluate the stresses in the shell of a pressure vessel, operating under internal pressure, induced by circumferential stiffening rings.

Normally, a stiffener of any sort is thought of as stiffening a part with a subsequent reduction in stress, as compared with an identical unstiffened part. In the case under consideration ring stiffeners cause a stress in the shell adjacent to the ring, which may be as high as 2·04 times the maximum hoop stress in an unstiffened shell of identical size. The stress adjacent to a ring stiffener is local and fades rapidly with increasing distance from the ring. In no case will a ring stiffener decrease the stress below that which would occur in an unstiffened shell, unless the spacing of the rings is such that the influence of one extends to the next.

A stiffening ring causes a longitudinal bending stress in the shell adjacent to the ring, which is compressive at the outer wall and tensile at the inner wall. In addition to this bending stress there exists a longitudinal membrane (direct) stress due to the pressure acting on the closed ends of the vessel, this stress being tensile. The sum of the longitudinal direct stress and the longitudinal bending stress is maximum at the inner wall by virtue of the fact that both stresses are tensile ; accordingly, this paper considers only the total stress in the shell adjacent to the ring stiffener at the inner wall.

A chart is presented for the determination of the maximum stress adjacent to a circumferential ring stiffener on a thin-wall cylindrical pressure vessel. It has been assumed that the pressure is internal, acts longitudinally as well as radially, and that the ring-stiffener spacing is such that the influence of one does not extend to the next.

Stresses are given in terms of stress ratio, which is the ratio of the total stress (direct plus secondary) adjacent to the stiffener to the hoop stress in the unaffected portion of the shell.

The History and Development of Hydraulic Transmissions for Marine Propulsion.

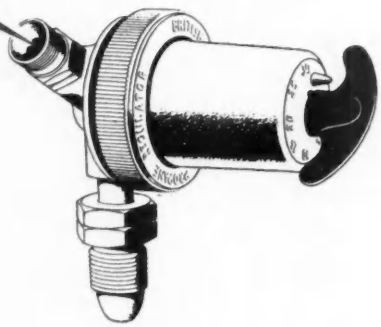
By D. FIRTH. (From a paper presented at a meeting of the *North-East Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne*, February 21, 1958, pp. 285–310, 15 illustrations.)

HYDRAULIC transmissions can be divided into two main groups, i.e., hydrokinetic and hydrostatic. Both types, which have their advantages and disadvantages, have been in existence for more than half a century but, whereas the hydrokinetic type had an immediate application, the hydrostatic transmission has only recently been applied to marine propulsion.

The paper surveys this field and discusses contemporary interest in the application of both forms of transmission to marine propulsion. It also discusses what use might be made of them in the future. Thus, for marine propulsion it would seem that the future application of hydrokinetic transmissions will be limited to special cases where some inherent advantages over gearing are worth the slight loss in efficiency or, as in the case of the jet pump, the use of a hydrokinetic transmission simplifies the engineering construction. Developments aimed at extending the reduction ratio of hydrokinetic transmissions would present considerable, but by no means impossible, problems.

In the sense that hydrostatic transmissions in the smaller ranges are becoming competitive with electrical systems and yet offer savings in space, weight, and reversing time, it is more than likely that the use of hydrostatic transmissions for marine propulsion will grow. The present limit on size will change as more knowledge about the effects of size on design becomes available and as the range is extended in industrial applications. In the very small portable-size range, competition and simplified manufacturing techniques will make the hydrostatic transmission increasingly attractive.

FROM BRITISH OXYGEN—
FOR BRITISH INDUSTRY



New propane regulator

The P.R.I. is a single stage regulator designed for use with propane and other gases. It may be used for heating and cutting purposes and has been specially developed for steel works, shipbuilding yards and heavy industry, to withstand heavy duty without fatigue. Write for fully illustrated literature.

BOC **BRITISH OXYGEN** | British Oxygen Gases Ltd., Industrial Division, Spencer House, 27 St. James's Place, London, S.W.1

The advantages of the hydrostatic drive over other transmissions are apparent at the lower speeds, but only when used with multiple engines and multiple motors. This saving at low speeds and the ease of control possible with hydrostatic drives confirm their attractiveness for duties where these virtues can be exploited. At the higher speeds nothing is, at the moment, as good as direct gearing, but in this case it is quite possible that the hydrostatic transmission is no worse than its electrical equivalent. The fixed-ratio hydrostatic transmission, throttle-controlled, gives the lowest efficiency of the transmissions under consideration. This underlines the fact that it is the variable transmission-ratio characteristic of a hydrostatic transmission which is one of its most exploitable features.

The Application of Servo-Mechanism Analysis to Fuel-Control Problems.

By J. O. N. LAWRENCE. (From a paper presented at a meeting of *The Institution of Mechanical Engineers, London*, February 14, 1958, 22 pages, 25 illustrations.)

IN detail, the gas turbine has many intricate aspects and its evolution, as well as that of its fuel system, has been described in many papers. Consideration of the fuel and control system in too great detail is not the purpose of this paper and would result in the trend of servo-analysis argument being lost. The object of the paper, on the other hand, is to bridge the gap between the specialist applications of servo-mechanism theory to electrical network problems, chemical plant, or other specialist fields, and the detailed consideration of the gas-turbine fuel systems, while the use of an advanced theory on a basically simple application in another field may serve to show the power and value of the technique and its adaptability to different circumstances.

The paper gives details of the way in which servo-mechanism techniques have been applied to accessory control problems. The emphasis has been on the correlation of theory with practice, and typical results are given from tests on some fifteen British gas-turbine engines. For completeness, a brief introduction to the basic concepts is first dealt with, followed by examples of linear and non-linear theories applied to typical working systems. It is pointed out that, though the examples refer to hydraulic, mechanical, and thermodynamic processes, the ideas may be carried forward into widely differing fields.

Some Shrouding and Tip-Clearance Effects in Axial-Flow Compressors.

By J. L. JEFFERSON and R. C. TURNER. (From a paper presented at a meeting of the *North-East Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne*, pp. 235–284, 43 illustrations.)

IN this paper, detailed descriptions are given of four series of tests carried out at the National Gas Turbine Establishment in connection with axial-flow compressors. Various combinations of shrouding and tip clearance were investigated, untwisted constant-section blading being used in the first three series. The experiments were carried out over a range of shrouding leakage clearances, and also included an investigation of the boundary-layer flow on the convex surface of a stator blade in the compressor.

The conclusions derived from this investigation are as follows :—

(1) If a compressor-blade row is working under near-stalling conditions at its extremities, the use of shrouding may aggravate the tendency to local stalling, with consequent loss of efficiency. The effect increases as the shrouding leakage clearance increases.

(2) Under the same conditions, the use of a very small radial tip clearance will also aggravate the tendency to local stalling. It appears that a moderate amount of normal radial tip clearance (e.g., of the order of 1% of the blade height) is beneficial in this respect.

(3) Shrouding should not be used if the velocity profile is such as to cause local stalling, as, for instance, in the rear stages of a multi-stage compressor or in a compressor containing constant-section untwisted blading.

(4) If it is necessary to use shrouding, it should have the smallest practicable leakage clearance, in order to maintain the efficiency at a reasonable value.

(5) The use of constant-section untwisted blading, even with a normal radial tip clearance, is not generally advisable, since it has a marked tendency to stall at the inside diameter.

(6) An increase in the normal radial tip clearance on a fairly highly loaded compressor above 1% of the blade height results in a severe drop in performance. Smaller clearances were not investigated in these tests.

(7) An increase of clearance in both shrouded and radial tip clearance blading results in a decrease of surge flow in the multi-stage compressors investigated.

(8) Further work could usefully be carried out on the details of the effects of radial tip clearance and shrouding on the flow through the blade passages in multi-stage compressors.

New Oxidizing Method, using Borax, for Revealing Austenitic Grains

(*Concluded from page 107*)

Consequently, a series of comparative tests was initiated to determine the effect of dissolved nitrogen on grain size, using both the thermal-etching method and the new method. The results obtained were remarkably similar for all grain sizes observed, and showed that the new method can safely be used for determining grain size.

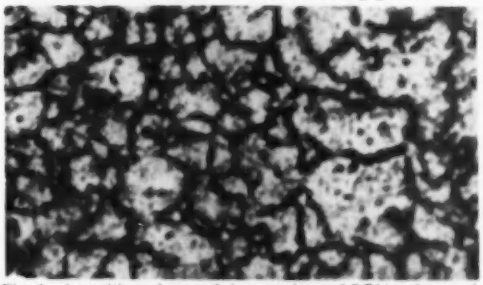


Fig. 4. Austenitic grain growth in a specimen of 0·7% carbon steel, austenitized at 950°C for 3 hr and etched by the new method. (×110)

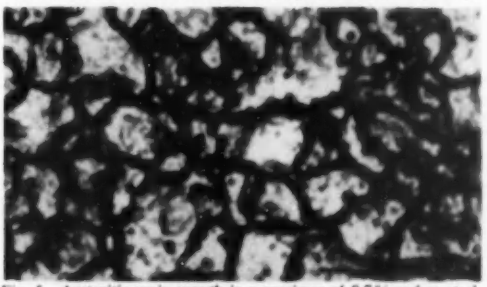
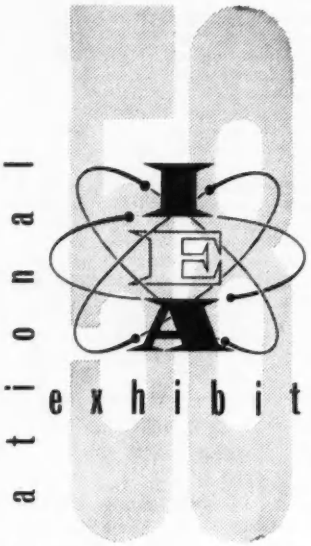


Fig. 5. Austenitic grain growth in a specimen of 0·7% carbon steel, austenitized at 1000°C for 3 hr and etched by the new method. (×110)

In addition, tests were carried out to determine the effect of austenitizing temperature on grain growth, and the results with a 0·7% carbon steel are shown in Figs. 4 and 5. In both cases, the specimens, after austenitizing, were immersed in borax at 900°C for 20 sec, but, in the case of the specimen in Fig. 4, austenitizing was at 950°C for 3 hr, while, in the case of that in Fig. 5, it was at 1000°C for 3 hr. The increase in grain growth of the specimen austenitized at 1000°C is clearly visible.



international exhibition

INSTRUMENTS ELECTRONICS AUTOMATION

16-25 APRIL 1958 OLYMPIA LONDON
admission 2/6
10 a.m.-6 p.m. daily (until 9 p.m. Fri. 18th & Wed. 23rd)

You will be welcome at the 1958 Instruments, Electronics and Automation Exhibition.

MORE THAN 250 BRITISH MANUFACTURERS will be showing the latest and most comprehensive range of exhibits.

OVER 100 OVERSEAS EXHIBITORS will be displaying their achievements in the rapidly developing fields of instruments, electronics and automation. Note the date **NOW.**

I.E.A. — the exhibition no progressive industrialist can afford to miss.

A conference will be held throughout the period of the I.E.A. Exhibition. Further information regarding both conference and exhibition will be gladly supplied by the organisers:

INDUSTRIAL EXHIBITIONS LIMITED
9 ARGYLL STREET, LONDON, W.1 Tel: Gerrard 1622

See the latest developments

at the Sixth

Factory Equipment

Heating, Ventilation & Thermal Insulation

Exhibition

EARLS COURT · LONDON

APRIL 14-19

10 a.m.—7 p.m. (Saturday 5 p.m.)
Admission 2/6d

All concerned in any way with industry should make time for at least one visit to this important exhibition—the greatest of its kind ever held.

ADMISSION TICKETS FOR READERS OF THIS JOURNAL

Fill in this coupon or send us your letter heading

To The Organiser, Factory Equipment Exhibitions Ltd., Dept. 27, 4, Snow Hill, London, E.C.1. *Please send me free of charge admission tickets and brochure of the Sixth Factory Equipment, Heating, Ventilation & Thermal Insulation Exhibition.*

NAME _____

ADDRESS _____

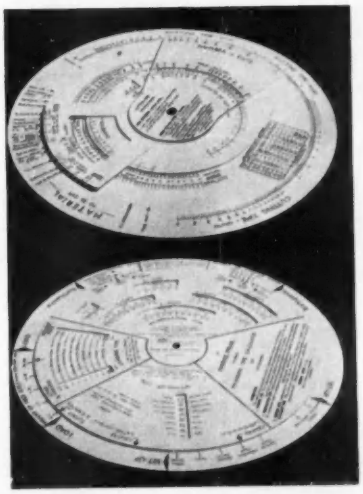
Sponsored by "Factory Equipment News" & "The Factory Manager"

New Materials, Processes, and Equipment

MACHINING-TIME CALCULATOR

A new kind of machining-time calculator, of the circular slide-rule type, announced by Fearns, Mear & Co., of Almondbury, Huddersfield, provides a rapid and accurate means of determining machining times for turned components of all kinds, produced on centre-lathes, turret and capstan lathes, and boring mills. The actual times required, including all normal allowances, are read off directly after simple setting of a few scales.

Cutting time is read off on one side of the calculator (shown at the top of the illustration) after setting the dials to the appropriate information, e.g., material, type of tool diameter of work, length of cuts, and number of cuts. Other dials on scales on the reverse side of the calculator (bottom of illustration) then give the time increments for loading, manipulation, gauging, etc., taking into account the necessary allowances for the type of work being undertaken. Setting-up times are also provided in a separate section.



The instrument, which is made of transparent and white perspex, with four-colour engraved scales, is suitable for any turned component between $\frac{1}{8}$ and 80 in. in diameter, and between $\frac{1}{16}$ and 200 in. in length, and is intended to be the first of a range of similar instruments for calculating times for all kinds of machining operations.

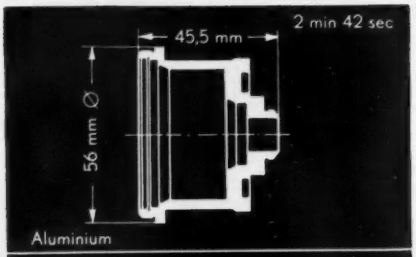
PORTABLE ELECTRONIC STRAIN INDICATOR

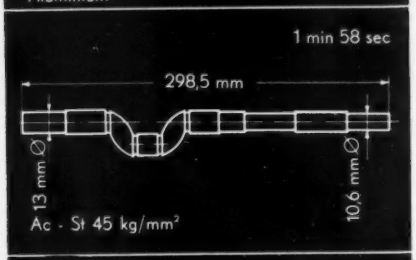
For use with special bonded resistance-wire strain gauges, a self-contained portable electronic strain indicator, recently developed by the Testing Equipment Department of the Baldwin-Lima Corporation, of Philadelphia, Penn., is designed and calibrated for an initial resistance of 120 ohms and a gauge factor of any value from 1·77 to 2·2. When used with gauges having these characteristics, the indicator reads directly in microinches per inch strain. For gauges with resistances other than 120 ohms, a simple curve gives the gauge-factor required for setting the gauge-factor dial to make the instrument read directly in microinches per inch. For nearly all practical work this refinement is unnecessary, since the gauge-factor correction is less than 1% over the range of resistances normally used.

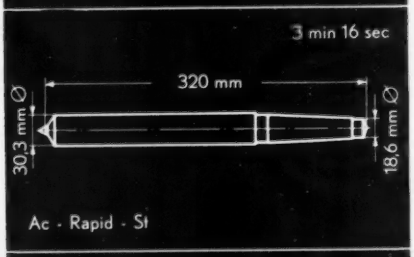
The measuring range of the balancing dial is 0 to 2000 microinches per inch. A " thousands " switch shifts the reference point of the balancing dial by 2000 microinches per inch for each step of the switch. The null-balance meter has an approximate range of 50-0-50 microinches per inch of strain, and a range-extender switch extends the balancing range of the instrument by approximately 20,000 microinches per inch in either direction beyond the ends of the range covered by the " thousands " switch. Normally, this is used only when the active and compensating gauges are very poorly matched in resistance, or when very large strains are measured, such as in the study of metals in the post-yield range of testing. Because of this extremely wide range, strains can be followed into the plastic region and to the rupture point in practically any metal, wood, or plastic. In addition, the need for careful resistance matching of strain gauges and lead wires is eliminated. The " thousands " steps have a tolerance of $\pm 2{\cdot}5$ microinches per inch. Slide-wire tolerance is $\pm$ 5 microinches per inch, and the gauge-factor adjustment is accurate to $\pm 0{\cdot}25\%$ at any point.

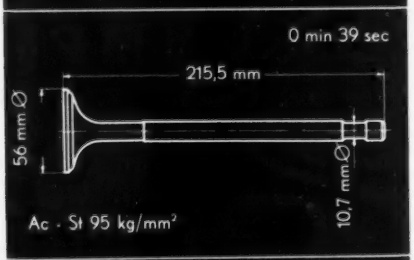
In certain strain-gauge investigations it is advantageous to connect the gauges into a closed external bridge circuit connected to the strain indicator by four lead wires. The effect of variations in cable and terminal contact resistance on the strain measurements thus becomes minimized, because both sources of error are then external to the gauge bridge. The external bridge also lends itself to increased measuring sensitivity in cases where it is practical to employ two active and two compensating gauges (connected alternately around the bridge loop). The indicated strain will then be just twice the actual strain, since the two active gauges will produce an additive effect in balancing the bridge. This arrangement has been used effectively where the strains to be measured are very small.

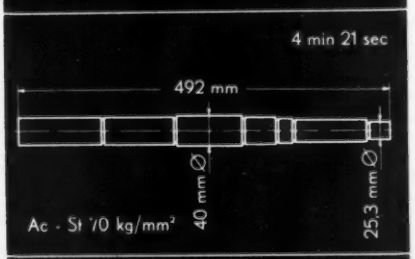
Although the indicator is designed as a null-balancing instrument for the measurement of static strains, provision is made in the front panel for the convenient and practical observation of dynamic strains with the aid of any standard cathode-ray oscilloscope, and for applications in the rephasing problems sometimes encountered

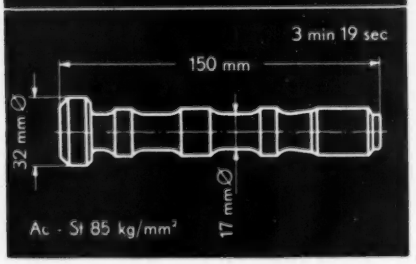












DUBIED

Hydraulic Copying Lathes

TYPE 514

8 spindle speeds through gear-box.

TYPE 515

Automatically-controlled variator gear for constant cutting speed.

Range of speeds:	350 – 4000 rpm
Distance between centres:	15¾" and 25⅝" (400 and 650 mm)
Motor:	5.5 – 7 HP

Dubied lathes permit the economical turning even of small batches of 15 - 20 workpieces.

Our specialists will be pleased to calculate the cutting times of your own parts, with a view to turning them on our machines, without putting you under any obligation.

Edouard DUBIED & Cie, S.A.

NEUCHATEL / Switzerland

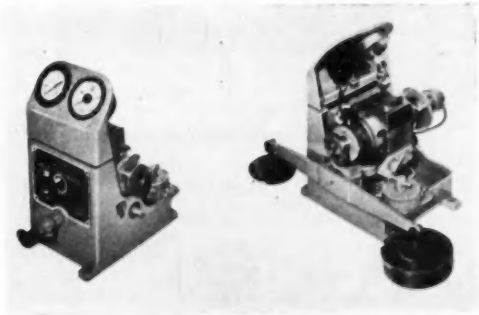
Telegrams: "EDCO", Neuchatel

when using extremely long leads (50 to 100 ft) between the strain gauges and the instrument.

Balancing controls have been reduced to a minimum and comprise the main balancing dial, the " thousands " switch, and the range-extender switch. The null-balance indicator and the operating controls are conveniently located for ease of manipulation and reading. A separate manual adjustment corrects the instrument calibration for gauge factor, so that the instrument reads directly in strain values. The only other adjustment on the panel is the power switch, which has battery-check positions. Battery conditions are read directly on the null indicator, with a clear marking to indicate when batteries should be renewed. An automatic safety switch opens the battery circuit whenever the instrument cover is closed, so that the batteries will not be accidentally discharged. An a.c. power-supply unit is also available, being a separate plug-in unit for mains operation and so arranged that the batteries need not be removed. Binding-post terminals are provided for use with either a single gauge or with companion switching units for multiple-gauge installations.

SIMPLIFIED HYDRAULIC DYNAMOMETER

To meet the requirement for a dynamometer for use where the highest degree of accuracy of power measurement is unnecessary, or where the actual power absorbed does not need to be measured, all that is required being some means of imposing a controllable load against the unit under test, so as to run it at various speeds and throttle openings, Heenan & Froude Limited, of Worcester, have introduced a new range of equipment, designated the I.E. brake or dynamometer, with sizes from 25 hp at 4600/6000 rpm to 100 hp at 2500/4000 rpm. The basic concept is of a brake unit on general Froude principles, without torque-measuring equipment, and with cast-iron feet to bolt directly to the user's bedplate or foundations, when only a simple power-absorbing unit is required, the unit being converted into a full-scale dynamometer by mounting it on a pivoted platform and by fitting a lever arm for measuring the torque-reaction forces.



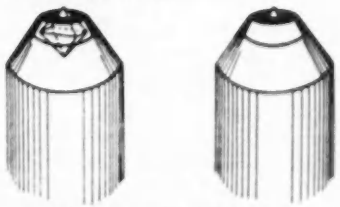
The power-absorbing elements (rotor and stator) of the brake unit embody standard Froude practice, but are of the single-sided type, instead of the more familiar double-sided type. The resulting axial thrust is self-contained and is amply within the capacity of the brake bearings. The load-control gear is also a departure from the sluice-gate type previously used in the smaller sizes of Froude dynamometers, in that the load at any particular speed now depends on the quantity of water discharged into the brake casing by a pump impeller mounted on the brake shaft. This quantity is regulated by a hand-valve fitted to the casing, and control is very stable and convenient. These two features, of single-sided power elements and the control gear, permit a greatly simplified and economical construction.

Another interesting feature is the design of the pivoting gear enabling the torque reaction on the brake casing to be measured. In previous conventional designs of small dynamometers, the casings have been allowed the necessary rocking motion between no-load and full-load by mounting them on trunnion bearings, which normally surround the shaft and hence must be of relatively large dimensions. In the I.E. design, they are replaced by pivot bearings located vertically below the shaft axis, and can thus be made much smaller. The resulting slight movement of the shaft itself necessitates a universally jointed cardan shaft between the engine and dynamometer, but such shafts are normally used in any case, and the type usually employed is easily capable of accommodating this movement. The brake unit on its pivoted platform is provided with a short lever arm, bearing upon a pressure capsule, coupled by small-bore piping to a pressure gauge calibrated to give torque readings. In conjunction with the tachometer readings of speed, the power absorbed can be calculated, and either British or metric units of horsepower may be specified. At full torque the accuracy is within $\pm$ 1%.

The torque dial and speed dial are normally fixed to the standard panel, which is itself flexibly attached to the dynamometer bedplate. The torque dial is supplied with 20 ft of small-bore piping, for remote mounting, if desired. The tachometer is of the electric type, and extended wiring to such a remote station will not affect its accuracy. By fitting the tachometer generator at alternate ends of the shaft, the dynamometer can be used for engines running in either direction of rotation. In addition, for quickly checking the accuracy of torque readings, a device, consisting of a quick-fixing lever arm and dead-weights, can be supplied.

NEW METHOD OF MOUNTING STONES IN DIAMOND TOOLS

A novel method of mounting stones in diamond tools, with savings in material of up to 90%, has been developed by the General Electric Co., of Schenectady, N.Y. In a conventional mount, as much as 90% of the diamond used may be buried in the tool, in order to gain rigidity and prevent loss of the stone. In the new method, a considerably smaller diamond is mounted in a shallow cavity on the surface of a single-point wheel-dressing tool. Formerly, a deep cavity would have been necessary, as shown in the illustration, which depicts (left) a conventional method of mounting a diamond, and (right) the new flush-mounting method.



One secret of the new method is the use of titanium hydride as a wetting agent and a solder, such as silver-copper, the parts being brazed by induction or radiation heating in a high-vacuum system, or in an atmosphere of very pure argon or hydrogen gas. In strength tests, a small diamond tip, mounted on a microtome blade and rotated at 56,000 rpm, produced a force of about 50,000 psi, without, however, dislodging the diamond.

The method already shows great promise of industrial use, its advantages being that (1) the diamond is more securely anchored to its mount ; (2) the wasted " root ", which in many cases is 75% of the volume of the entire tool point, can be eliminated ; (3) much smaller diamonds can be mounted to provide the same working surface ; and (4) heat transfer is better when a diamond is bonded to metal than when there is only a mechanical connection, so that the diamond has a longer life and is less likely to fracture from thermal shock.

dynamic technique

Your organisation, however efficient, needs the driving-power of up-to-the-minute technical knowledge. Let SMITH'S supply you with the books that you must have to keep you fully in touch with the newest engineering techniques and the latest advances in research and operational economy.

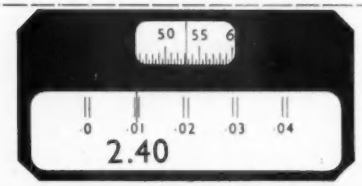
● *Volumes not in stock can be obtained for you, and we shall be pleased to supply a list of standard works on any subject.*

W. H. SMITH & SON

HEAD OFFICE : STRAND HOUSE, LONDON, W.C.2

BRANCHES THROUGHOUT ENGLAND AND WALES

Direct reading to 0.00005 in. on projection screen



All measurements with the Microptic Horizontal Measuring Machine are read in large clear figures from a 3¾ in. wide screen. Reading is simplified, setting more accurate, eyestrain eliminated. Ideal for use in Testing and Standards Rooms and for routine measuring of all types of internal and external work. Any number of measurements over a four inch range can be made with one standard setting. Capacities: Internal $\frac{7}{16}$ to 10 ins., External 0 to 13½ ins. Metric reading model available. Length 35 ins.; height 22 ins.; width 14 ins.

Write for list **ED/105**

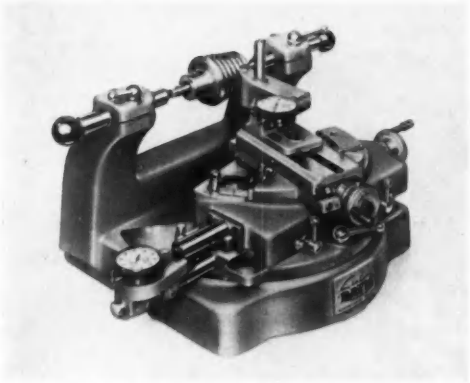
HILGER & WATTS LTD. 98 ST. PANCRAS WAY, LONDON, N.W.1. *Tel: GULliver 5636*

Makers of precision optical instruments for analysis, measurement and inspection. Member of the Export Marketing Company—BESTEC

HW/105

FLANK-ANGLE CHECKING MACHINE

Operating on the principle that standard worm-thread flanks are theoretically helical surfaces generated by a straight line, the new flank-angle checking machine, model FAC-1, announced by Stuart Davis Ltd., of Coventry, is primarily intended to check, by direct measurement, the form of involute helicoids and of helicoids, etc. which are straight-sided in the normal or axial plane. With this machine, a stylus actuates an indicator with a magnification of ×5, recording deviations from a straight-line generator when it is brought into contact with a flank. The head of the indicator, which is graduated in steps of 0·0001 in., may be raised to allow the stylus to be traversed in the correct plane pertaining to the straight-line generator.



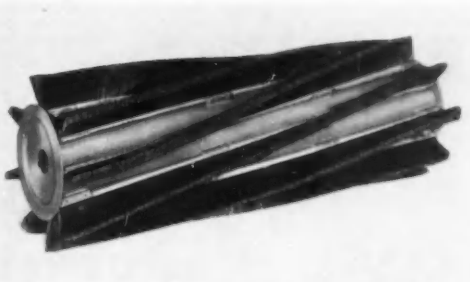
The unit is mounted on a cross-slide carried on a swivelling table which can be set to the required angle. In operation, the machine is set at zero, with the pivot of the indicating head adjusted to ensure that the stylus is on the axis of the workpiece centres, this operation being best accomplished by means of slip-gauges and a dial-gauge. For checking fine pitches, the stylus point is located on the axis of rotation. For checking helicoids, etc., straight-sided in the axial plane, the same setting applies. Involute helicoids can be checked by setting the stylus above the work axis by an amount equal to the base-circle radius and the swivelling table to the base head angle of the work. The bias of the stylus is set in accordance with the hand of the worm helix.

Among other operations, the machine can be used for checking parallel and taper hobs, measuring the angle or straightness of flank forms, measuring pitch parallel to the axis or taper, and measuring diameters.

ROTARY BRUSHES FOR REMOVAL OF CARRY-OVER FROM CONVEYOR BELTS

Stated to overcome all the difficulties encountered with conventional methods of combating the problem of carry-over, i.e., the material adhering to conveyor belts after they have passed over the header roll and unloaded, the new " Rota-Master " heavy-duty strip-type helically formed brushes announced by the Osborn Manufacturing Company, of Cleveland, Ohio, have a special sweeping action, quite different from that of ordinary rotary brushes, being designed with an interrupted face area, so as to allow the individual strip bushes to flex and clean themselves.

Various methods of installing the brushing unit are possible, depending on the conveyor, frame, and location of the header and snubber rolls. Thus, the unit may be driven by belts from the header roll, a counterweight being used to keep the brush in contact with the roll and a spring located to maintain uniform brushing of the conveyor surface. Alternatively, the brush can be driven by a separate motor, arranged to stop automatically when the conveyor is stopped, brush wear and pressure being made positively by a screw mechanism. This method is particularly recommended where tacky materials are being conveyed, as the screw arrangement ensures a positive pressure and good cleaning. Available in widths of 16, 18, and 24 in., these brushes can be ganged together to make up any required belt width.



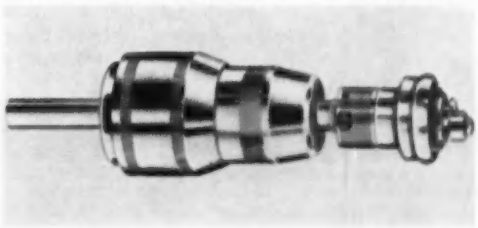
PRESSURE-IMPREGNATION FLAMEPROOFING TREATMENT FOR FIBREBOARD

Stated to be the first successful method of its kind ever devised, a patented pressure-flameproofing treatment for regular-grade fibre insulation board—always considered a serious fire hazard—is announced by Hickson's Timber Impregnation Co. (G.B.) Ltd., of Castleford, Yorks. Using a special flame retardant designated " Pyrolith ", the pressure-impregnation method employed ensures that the material treated can be cut or broken without revealing fibres, and involves none of the risks associated with surface-applied flame retardants, e.g., accidental washing off of the retardant or failure to treat all surfaces. Furthermore, " Pyrolith " in no way impairs the properties of the board ; in fact, it is stated that its thermal insulation efficiency is actually improved by the treatment. Insofar as its fire-resistant properties are concerned, tests have indicated that standard fibreboards pressure-impregnated with " Pyrolith " compare quite closely with non-combustible types of wall linings, including asbestos. In fact, the treated board not only provides a very high resistance to flame spread but also contributes insignificantly to the temperature rise of a conflagration as a result of its own combustion.

Production of standard fibreboards pressure-impregnated with " Pyrolith " has already been initiated, such treated boards being marketed under the trade name of " Pyrestos " fibre insulation board.

INTERNAL GROOVING TOOL

Designed for cutting grooves in bores, concentric to the bore diameter, and to very close tolerances, a grooving tool, recently introduced by Geo. Salter & Co., Ltd., of West Bromwich, can be used efficiently in lathes, milling machines, and drilling machines (including portable drills), and will operate either when it is rotating and the workpiece is static, or *vice versa*. Although it was designed primarily for the purpose of cutting grooves for retaining rings, it can also be used successfully to cut various shapes of grooves and, if necessary, to incor-



The Eclipse Range of tools includes:—

Hack Saw Blades and Frames . Sheet Saws . Surface Gauges
Automatic Centre Punches . Scribers . Tap Wrenches . Pin Vices
Pin Tongs . Angle Plates . Vee Blocks . Tool Bits & Tool Bit Holders
Saw Sets . Coping Saws . Junior Saws . Piercing Saws . Fret Saws
Jig Saw Blades . Trammel Heads . Instrument Vices . Pad Handles
Permanent Magnets Magnetic Chucks and Magnetic Tools

Made by James Neill & Co. (Sheffield) Ltd., and obtainable from all tool distributors

UX13

porate other operations, including chamfering, facing, or undercuts on threads.

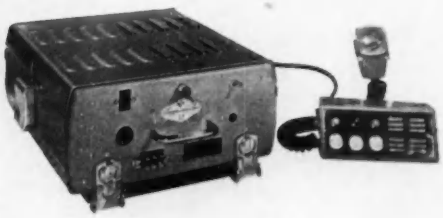
In a typical operation in conjunction with a drilling machine (on which it is most commonly used), as the spindle of the machine is lowered into the job, the bush in the gauge-head (or bottom adapter, as the case may be) pilots into the bore, locating the cutter in its position to initiate cutting the required groove. Continuation of the downward pressure of the machine spindle causes the cutter to move from its neutral position, in an eccentric movement, until the required depth of groove is attained, after which the machine spindle will not move any further, even though downward pressure is still applied. It should be noted that this "stop" action is within the tool itself and that no secondary stops are necessary, irrespective of the type of operating machine employed. As pressure on the spindle is relieved, the cutter returns to its neutral position, and the tool is then withdrawn from the bore of the grooved part.

An important point is that the tool, which is available in a range of five sizes, covering bore diameters from $\frac{3}{4}$ to 4 in., can be used with unskilled labour, without sacrifice of accuracy.

MOBILE TWO-WAY RADIO-TELEPHONES

The latest addition to the "Ranger" series of mobile two-way radio-telephone equipment produced by Pye Telecommunications Limited, of Cambridge, is a new heavy-duty unit which, despite its very long working range and transmitter output powers of up to 15 W with amplitude modulation and 20 W with frequency modulation, is designed to fit neatly and unobtrusively into any vehicle, boat, or railway locomotive. In fact, the main unit, about the size of a small suitcase, can be installed in the boot of a car or any similar out-of-the-way place, leaving only the compact control unit, which contains the loudspeaker and simple controls, to be mounted on the dashboard or in any other convenient position.

The new equipment is produced in four main types, i.e., 5 and 15 W A.M. versions, and 10 and 20 W F.M. versions. The A.M. equipment operates on channel spacings from 20 to 100 kcs, and the F.M. equipment on 50 kcs. All equipment will operate on single- or double-frequency simplex, or duplex on fixed frequencies in the 25 to 174 Mcs band, and models with up to six switch-selected channels are available. All types are suitable for use in any climate, including arctic and tropical, and are designed to meet all relevant national and international specifications.



The main unit is mounted on a cradle and can easily be withdrawn by releasing only two fasteners. The covers can be removed completely by undoing one sprung fastener, giving access to both the top and underside of the chassis. Identical mountings and covers are used for all four types, and common circuitry and components are used throughout the range, wherever possible, greatly simplifying maintenance and reducing the number of spare components necessary. The equipment is supplied complete with the control unit, mounting cradle, interconnection cables with plugs and sockets, co-axial feeder cable, and a quarter-wave whip aerial and base. For units operating between 25 and 68 Mcs, a special whip aerial with a heavy-duty spring base is provided. Optional extra features include a telephone handset in place of a fist microphone, shock-absorbing mountings for the main-unit cradle, and a mute which silences the loudspeaker when no signal is being received. A public-address loudspeaker, with an output of 12 W, can also be fitted to the A.M. equipment.

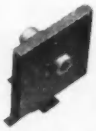
HIGH-FREQUENCY INDUCTION GENERATOR

Specially designed for silicon refining and for similar processes where a very high work-coil power output is essential, the new model C50/SR "Radyne" 6-kW induction generator announced by Radio Heaters Ltd., of Wokingham, Berks, operates at a nominal frequency of 5 Mcs and will develop a peak voltage in excess of 4500 V across a work-coil of 0·5 microhenry. By using a higher frequency than is normal for induction heating, it is possible to achieve a high work-coil power output without the use of a high-power generator, so that the relative efficiency of the process is high, and the capital cost low.

The equipment is designed for use with work-coils of from 0·3 to 1·0 microhenry and, as the work-coil forms the actual tank-coil of the oscillator, the operating frequency will vary between 3·5 and 6·5 Mcs. A manual power-output control is provided in the form of a separate self-contained voltage regulator, which feeds the primary of the high-voltage transformer and provides the means of varying the anode voltage fed to the oscillator valve down to 25% of the normal value of 5·5 kV d.c. This regulator can also maintain, if desired, a constant output at any predetermined voltage setting over its control range.

An additional facility can be provided whereby the output of the generator is reduced almost instantaneously from 6 to 1 kW. This is achieved by initially bypassing the voltage regulator and then, by means of a contactor sequence, switching in the regulator, which has previously been set for reduced voltage. This facility is most useful for initiating the process cycle when silicon refining. Thus, provided that the silicon rod to be processed is not of a high purity, it will be possible to heat the rod from cold without the necessity for preheating by conduction or other methods. Once the rod commences to heat, however, its resistance decreases rapidly, resulting in an accompanying sudden increase in temperature rise. By depression of a push-button, the voltage regulator can be switched into circuit, thereby instantaneously reducing the power input to the silicon to a predetermined value, to match the change in the characteristics of the material and the traverse speed for refining.

Illustrating the extreme hardness of SINTOX Industrial Ceramic, the photograph on the right shows a ¼" dia. tube of SINTOX which, without even chipping, was forced through ¼" thick mild steel plate.



SINTOX IN ENGINEERING

SINTOX MECHANICAL APPLICATIONS.
The many mechanical applications of SINTOX industrial ceramic will be of immense interest to the designer and mechanical engineer. The remarkable resistance to abrasion of SINTOX makes it particularly suitable for such uses as inserts and supports at points where rapid wear presents a problem. Already it has made a name for itself in the Textile industry, where the advent of artificial fibres brought entirely new problems. Thread guides made of SINTOX have been proved to have up to a hundred times the life of those made of hardened steel.

THE HARD CERAMIC **SINTOX**

STAS

SINTOX TECHNICAL ADVISORY SERVICE

This service is freely available, without obligation, to those requiring technical advice on the application of Sintox Industrial Ceramics. Please write for booklet or any information required enclosing blue print if available.

SINTOX IS MANUFACTURED BY **LODGE PLUGS LTD., RUGBY.**

CONSOLIDATED PNEUMATIC MAKE OVER 480 DIFFERENT MODELS OF POWER TOOLS

This is the C.P. IMPACT WRENCH Model 344-RS

IT CUTS OPERATING TIME FROM MINUTES TO SECONDS

Whether running up ¼" nuts in thousands or driving 1¼" nuts on heavy work, there's a C.P. pneumatic Impact Wrench to reduce the time and costs of the job. The impact clutch eliminates torque reaction and the final torque obtained can be accurately controlled by pressure regulation. C.P. Impact Wrenches can also be used for tapping, stud-setting, screwdriving, drilling or reaming. Ask for the Impact Wrench section of Catalogue No. 50.

Consolidated Pneumatic

AIR COMPRESSORS
PNEUMATIC TOOLS
ELECTRIC TOOLS
CONTRACTORS EQUIPMENT
ROCK DRILLS
PUMPS
DIAMOND DRILLS

CONSOLIDATED PNEUMATIC TOOL CO., LTD., 232 DAWES ROAD, S.W.6

NEWS OF THE MONTH

PERSONAL

Mr. P. W. Howard, managing director of BTR Industries Ltd., of London, S.W.1, has also been appointed Deputy Chairman of the Board. **Mr. J. S. Exley** has been appointed Manager of Marketing of the company's Conveyor and Transmission Belting Division.

Dr. John Douce, of Manchester University, has been retained by Servomex Controls Ltd., of Crowborough, Sussex, as consultant on theoretical problems arising in the field of non-linear control systems and of systems subject to random fluctuations.

Mr. J. H. Mayes, general sales manager of the Northern Aluminium Company Ltd., of London, W.C.2, has been appointed to the board of directors.

Mr. George C. Fairbanks, M.I.P.E., a deputy general manager of Elliott Brothers (London) Ltd., has been appointed a director of the company.

Mr. Arthur Cyril Yeates, M.I.Mech.E., M.A.Mar.E., A.M.I.E.E., has been appointed chairman of Crossley Premier Engines Ltd., of Sandiacre, near Nottingham, in succession to the late **Sir Kenneth I. Crossley, Bt.**

Mr. H. E. Bayman has retired from his position as manager of Exide and Drydex Replacement Sales in the U.K. after 25 years service with Chloride Batteries Ltd., of London, S.W.1.

Mr. R. S. Medlock, B.Sc., A.R.I.C., A.M.I.Mech.E, A.M.I.E.E., has been appointed Technical and Home Sales Director of George Kent Ltd., of Luton, Beds., assuming responsibility for the Contracts Department, Home Sales Representatives, and Service and Erection, in addition to his duties as director in charge of Research and Development. A new central organization for Kent products in Australia will be under the direction of **Mr. E. E. Cook, M.Inst.F.,** whose position as Home Sales Manager is being taken over by **Mr. J. Tham. Mr. K. Scanes,** previously Exhibitions Manager, has taken over from Mr. Tham the responsibility for relations with overseas subsidiary companies, while **Mr. W. G. Askew,** Publicity Manager, has assumed responsibility for the Exhibitions Department. **Mr. L. A. C. Bartlett, A.M.I.Mech.E.,** has been appointed director of the Steering-Gear Division, and is relinquishing his duties as Commercial Director of the Instrument Division. **Mr. W. T. H. Carter** has been appointed chief buyer for the Instrument Division.

Mr. L. H. Cooper, chairman of The Mond Nickel Company Limited, of London, S.W.1, and vice-president of the International Nickel Company of Canada, Limited, has been elected a director of the latter company.

Mr. E. G. James, B.Sc., A.M.I.E.E., personal assistant to **Mr. G. S. C. Lucas,** director and chief electrical engineer of The British Thomson-Houston Co. Ltd., of Rugby, has retired after 39 years service with the company.

Mr. A. A. Kay, A.M.Brit.I.R.E., has been appointed assistant chief engineer of the Radio and Television Division of the Plessey Company Limited, of Ilford, Essex.

Mr. B. A. Hensler, managing director of Siemens Edison Swan (Export), Ltd., has been appointed to the board of directors of Siemens Edison Swan Ltd., of London, W.C.2. Mr. Hensler is also on the boards of the company's overseas subsidiaries and the board of Associated Electrical Industries (Overseas), Ltd.

Mr. H. Sellers has been appointed commercial manager of Livingston Laboratories Limited, of London, N.19.

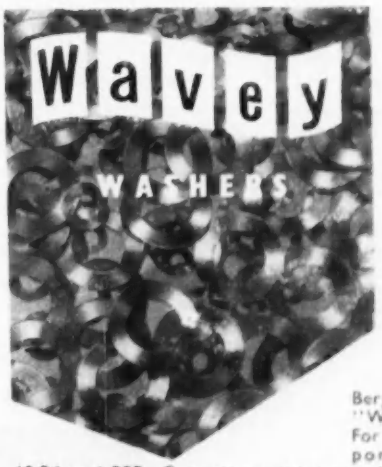
Mr. A. R. Mathias has been appointed chairman of the Lead Development Association for the current year, succeeding **Mr. H. L. Evans,** who had held this office since January, 1956. **Lt. Col. W. E. Grey** has been reappointed chairman of the Lead Sheet and Pipe Section of the Association.

Mr. R. B. Long has been appointed assistant export manager of A.C.V. Sales Ltd.

Mr. Norman F. Brand has been appointed to the board of Heyes & Company Limited, of Water-Heyes Electrical Works, Wigan, and will be responsible for sales management. He is succeeded by **Mr. John Heyes** in the position of chief engineer.

Mr. Allen A. Scaife, M.I.Mar.E., A.M.I.N.A., M.Inst.P.I., has been appointed managing director of H. Widdop & Co. Ltd., of Keighley, one of the members of the Associated British Engineering Ltd. group of companies. Mr. Scaife succeeds **Mr. J. T. MacLeod, J.P.,** who is retiring after 33 years of service with the company.

Mr. A. V. Sowman, M.I.E.E., has been appointed the first managing director of Crompton Parkinson (Chelmsford) Ltd., a recently formed subsidiary company of Crompton Parkinson Ltd. Mr. Sowman was previously a director and general manager.



Beryllium Copper "Wavey" Washers. For Electronic Components. Range 10 BA to ¼ BSF. Corrosion resisting, non-damaging to components, higher resistance of "set", higher recovery of load, permanent spring action. They are fabricated from Beryllium copper, heat treated to VPN 350 minimum, Electro Plated to DTD.924, Cadmium Plated to DTD.904 and Passivated to DTD.923. Samples and price lists on request.

THE LEWIS SPRING CO. LTD
RESILIENT WORKS, REDDITCH
TEL: REDDITCH 710/PBX
London Office: 122 High Holborn, W.C.1 · Tel: Holborn 7470 & 7479

LEAVE IT TO **Lewis** OF REDDITCH
SPRINGS SPRING CLIPS PRESSWORK WIRE FORMS VOLUTE SPRINGS

FBC SPECIALS

. . . the key to a fuller life

Performance in many branches of engineering is getting very intensified, and what once passed as normal bearing practice is now as inadequate as a wooden wheel on a 100 m.p.h. car.

Some machines start out by packing enormous power into a small and often hot space, and there—as in some of the finest jet engines in the world—you will find FBC 'Specials' often running at fantastic speeds.

Other machines in the course of time get 'hotted up' to give far greater power or output—yet it is seldom that the original design has the space to take bigger bearings.

Here again FBC 'Specials' are saving the situation—for it is amazing what exacting duties can be carried out by the right kind of bearing, when one is really 'up against it' and enlists the aid of the right people.

Our engineers—to whom, of course, we have just referred—will always assist in the design and manufacture of 'Specials' to suit customers' problems.

FISCHER BEARINGS CO. LTD., WOLVERHAMPTON

Fischer Bearings Company Ltd., and Timken-Fischer Stockists Ltd., Birmingham, are both subsidiaries of British Timken Ltd.

F.B.C. :: FISCHER
Reg'd. Trade Marks

Mr. J. I. Paton has been appointed sales manager of the Carron Company, of Falkirk, Stirlingshire. **Mr. W. Thompson** has been appointed chief technical representative, and **Mr. J. MacPherson** works manager of the Engineering Department.

Mr. L. A. Stevens has been appointed manager of a newly formed materials-handling department at F. Perkins Ltd., of Peterborough, and will be directly responsible to the deputy general manager of the manufacturing division.

Mr. S. G. Medcraft, formerly London sales representative of Fielding & Platt Limited, of Gloucester, has been appointed sales manager of the company.

Mr. T. H. West has been appointed Press Relations Officer to E. M. I. Electronics Ltd., of Hayes, Middlesex, and will be responsible for co-ordinating all the company's publicity activities.

Mr. B. W. Dawkins has been elected chairman of the Saxon Engineering Company Limited and Bennis Mechanizations Limited, both of Fenton, Stoke-on-Trent, and subsidiary companies of Bennis Combustion Limited, of whom Mr. Dawkins is joint managing director.

SIR HOLLAND GODDARD

It is with regret that we announce the sudden death in London of Sir Holland Goddard, president of Wadkin Ltd., of Leicester, on January 30, 1958, at the age of 75 years. Sir Holland was until recently chairman of the Imperial Typewriter Co. Ltd., Leicester, and the National Steel Foundry (1914) Ltd., Leven. In addition, he was a member of the Machine Tool Industry Council, the Grand Council of the Federation of British Industries, the Management Board of the Engineering and Allied Employers National Federation, the Council of the Production Engineering Research Association, and a number of other local and national bodies, and had been President of the Machine Tool Trades Association.

MR. A. E. HUKINS

With regret, we announce the death, on February 2, 1958, of Mr. Alexander Edwards Hukins, the founder and former managing director of the E.N.V. Engineering Co. Ltd., of London, N.W.10. Mr. Hukins did considerable pioneering work in producing the E.N.V. engines which powered many early experimental aircraft before World War I. Later, he took a prominent part in building up the British precision gear industry and was closely associated with the introduction and manufacture of spiral bevel gears.

MR. K. D. MARSDEN

We regret to record the death on February 2, 1958, of **Mr. K. D. Marsden,** who, for more than thirty years, represented J. A. Crabtree & Co. Ltd., of Walsall, Staffs., in North Wales and Lancashire. Mr. Marsden, who was born in 1898, received his early engineering training with the Renault Company of France, and joined the Crabtree Company in 1925.

MR. J. S. RAMSDEN, M.I.E.E.

We regret to announce the death, on February 22, 1958, at his home in Chatsworth Gardens, Eastbourne, of **Mr. John Scowcroft Ramsden, M.I.E.E.,** who, until his retirement in 1950, was on the board of directors of the British Thomson-Houston Company Ltd., of Rugby. Mr. Ramsden, who was elected a director in 1935, served the company for forty years, fifteen of them as a senior commercial director.

BUSINESS NOTES

Formed to carry out the installation and service of lifts manufactured by **Marryat & Scott Ltd.** and electrical installation work of **Marryat & Place Ltd.** in East Africa, **Marryats East Africa Ltd.,** one of the **Marryat & Scott Holdings Ltd.** group, has now commenced operations in Nairobi with the installation of lifts in the new Embasaki airport.

It is announced by **Henry Meadows (Vehicles) Ltd.,** of London, W.C.1, that, following the recent work on development of the "Frisky" car, the pre-production and planning stages have been completed, and commercial production of these cars has now commenced at the Park Lane Works, Wolverhampton. To meet overseas demands, arrangements have been made in conjunction with the motor trade organization known as the **Flower Group** in the Middle East. This group has acquired a controlling interest in the company, with Mr. Raymond Flower as chairman and managing director. Mr. Neville Flower has also joined the board.

Radiation Ltd., of London, W.1, have entered into an agreement entitling them to manufacture for the British market and certain overseas territories the wide range of warm-air appliances devised by the **Eureka Williams Corporation of America.** The agreement also provides for the mutual exchange of technical information on design and production methods.

The address of **The Professional Engineers Appointments Bureau** is now 39 Victoria Street, London, S.W.1. (Telephone : ABBey 1737).

The **Electrical Remote Control Co. Limited** has now moved to a new factory at Tye Green, Harlow New Town, Essex. The new premises will also accommodate **Equipment and Services Ltd.**

New offices have been opened by **W. E. Sykes Ltd.,** of Staines, Middlesex, at Grove House, Sutton New Road, Erdington, Birmingham 24 (Telephone : Erdington 7491). The company's Midlands representative, Mr. P. Franks, is now operating from these offices, which are intended to improve the facilities and services available to customers in the Midlands.

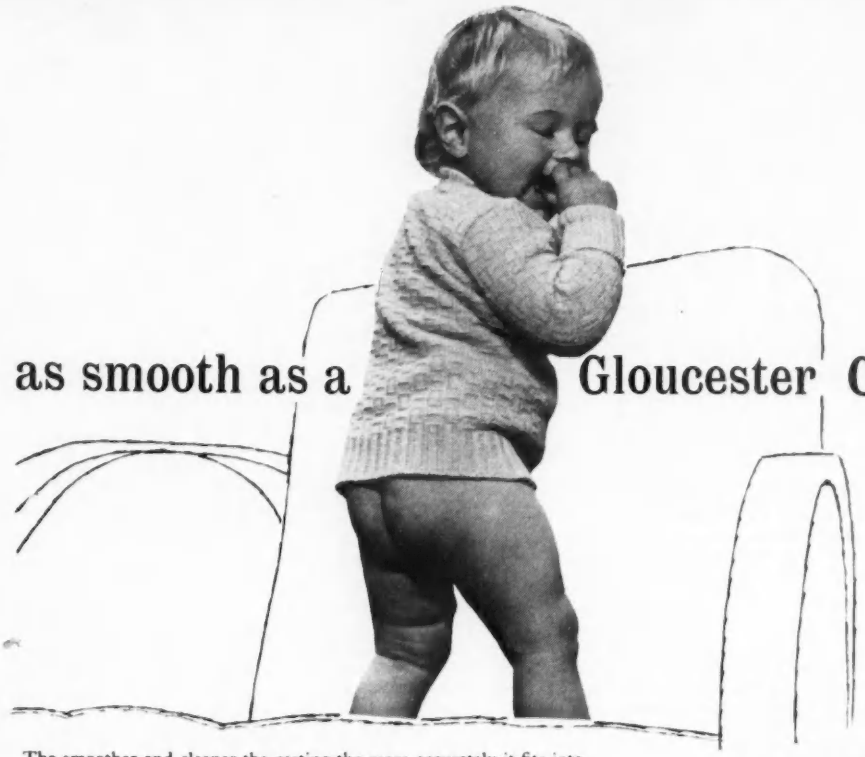
It is announced by **George Cohen Sons & Company Limited** that they have purchased the whole of the machine-tool plant which has become available as a result of the decision of **Associated Commercial Vehicles Ltd.** to close down the works of **Crossley Motors Ltd.** at Stockport.

An additional exchange line has been connected at the Aberdeen branch office of **British Insulated Callender's Cables Limited,** the new telephone numbers being Aberdeen 53351/2. The new address of the Glasgow office of **British Insulated Callender's Construction Company Limited** is 110A Maxwell Avenue, Westerton, Bearsden, Glasgow (Telephones : Bearsden 2382 and 2383).

A new company, **Yorkshire Imperial Metals Ltd.,** representing the amalgamation of the copper and alloy tube, fittings, and plate activities of the **Yorkshire Copper Works Ltd.** and of **Imperial Chemical Industries Ltd.,** has been formed, the registered office of the new company being at Haigh Park Road, Leeds. The board of directors is constituted as follows :— *From I.C.I.,* Dr. James Taylor (chairman), Peter T. Menzies, Dr. Maurice Cook, Michael J. S. Clapham, St. John Elstub, Harold Royle, and Walter N. Ismay. *From Yorkshire Copper,* George P. Norton (deputy chairman), H. F. Sherbourne (managing director), W. R. D. Macdonald, C. G. Robinson, Donald Fraser, J. Christie, and Clifford Breckon. The company's secretary is P. D. Peel Yates.

Decca Radar Limited and **The Decca Navigator Company Limited** announce that the new address of their head offices is Decca House, Albert Embankment, London, S.E.11 (Telephone : RELiance 8111).

as smooth as a Gloucester Casting



The smoother and cleaner the casting the more accurately it fits into the machining jigs allowing saving of time during machining process. At Gloucester, Malleable iron castings are as clean as modern science and machines can make them.

Superb core making equipment, careful analysis of sand at every stage of the core making and moulding processes, the use of special mould and core dressings, ensure clean castings, even as they leave the "knock out" bay for final fettling.

The elevator type electric-furnace anneals in 48 hours instead of the usual 7 days. It also allows greater control of the casting during annealing, resulting in uniformity of metal, greater strength, and — a smoother, finer skin.

Gloucester can handle large runs of malleable and grey iron castings for the automobile, railway, electrical and farming industries.

Gloucester are always willing to visit customers and help in the design of castings to save time and cost in production.

Spring mounting bracket in Malleable Iron Weight 8½ lbs.

Vehicle pinion housing in Malleable Iron. Weight 28 lbs.

A typical Gloucester Malleable specification.

Gloucester Blackheart Malleable		*Gloucester Lamellar Pearlitic Malleable*	
Elongation	18%	Elongation	5%
Yield Point	12 tons	Yield Point	24 tons
Tensile Strength	25 tons psi	Tensile Strength	35 tons psi

GLOUCESTER

Gloucester Foundry Ltd., Emlyn Works, Gloucester · Telephone : Gloucester 23041 · Telegrams : 'Pulleys' Gloucester

(A subsidiary of the Gloucester Railway Carriage & Wagon Co. Ltd.)

The new factory now being built for **Semiconductors Ltd.**, at Cheney Manor, Swindon, Wilts., will, it is claimed, be the most modern transistor plant in the world. Design and construction of the plant, which will be completely air-conditioned to minimize dust, is by **Richard Costain Ltd.** and the main construction work is now almost complete. Of unusual appearance, the factory will be clad entirely with aluminium panelling and will have no windows, while all internal surfaces will be coated with P.V.C. The installation of equipment will commence shortly, and it is anticipated that the factory will be in production in mid-1958.

Sir W. H. Bailey & Co. Ltd., of Patricroft, Manchester, have been appointed sole distributors for the range of flow-indicating equipment produced by the **Dukes and Briggs Engineering Co.** At present, this equipment comprises their " Telicator " visual flow indicators, but other models, providing a full range of flow indicators to cover all requirements, will shortly go into full-scale production.

To provide on-the-spot representation in the Bristol area, **Kerry's (Great Britain) Ltd.**, of London, E.15, have acquired a suite of offices in the recently completed Royal London Buildings, Baldwin Street, Bristol. Mr. F. Barrett has been appointed manager of this Bristol branch.

It is announced by **E. P. Barrus (Concessionaires) Ltd.**, of Acton, London, W.3, who introduced " Devcon " plastic steel to Great Britain two years ago, that this material, which was previously available only under licence from the U.S.A., is now being manufactured within the Commonwealth. To provide stocking facilities, two new companies have been established, and these, in association with the home company at Acton, will cater for requirements in England, Scotland, and Northern Ireland. The new companies are respectively **Small-Barrus Associated,** 21/23 India Street, Glasgow 2 (Telephone : City 3301), who will cover Scotland and Northern Ireland, and **Tasker-Barrus Associated,** Blonk Street, Sheffield, who will operate in South Yorkshire, Derbyshire, Nottinghamshire, and Lincolnshire.

The new address of the Midlands office of **Wild-Barfield Electric Furnaces Ltd.** is 71 Broad Street, Birmingham 15 (Telephone : Midland 7232).

A subsidiary company has been established in Holland by **Black & Decker Ltd.**, of Harmondsworth, Middlesex, to provide a complete repair and maintenance service for their electric tools. The new company is known as **Black & Decker (Nederland) N.V.**, and its address is 109 Vondelweg, Rotterdam.

Twiflex Couplings Ltd., a subsidiary of **Sheepbridge Engineering Ltd.**, of Chesterfield, announce that **Caselco Ltd.**, of 46 Park Square, Leeds (Telephone, Leeds 3-0285/6 or 3-1146), have been appointed sole selling agents of the complete range of Twiflex products in Yorkshire.

CONTRACTS

The Canadian Government has announced that it has placed an order for ten " Cosmopolitan " medium-range transport aircraft with **Canadair Ltd.**, of Montreal, as a step towards the modernization of the facilities of the R.C.A.F. Air Transport Command. The Cosmopolitan is a combination of the airframe of the American Convair airliner and the British "Eland" propeller-turbine designed and built by **D. Napier and Son, Ltd.**, a member of the **English Electric Aviation Group.** Deliveries of the Cosmopolitan to the Royal Canadian Air Force will begin in 1959. The Eland engines, which will be manufactured in Napier's Liverpool factories, will be supplied as complete powerplants to the Montreal factory of Canadair. The value of this initial Canadian order for Napier engines is between 4 and 5 million dollars.

A.C.V. Sales Export Division announce that the largest order (8½ million dollars) ever placed by the Montreal Transport Commission has recently been received by the **Canadian Car Co. Ltd.** for 325 buses, all of which are to be fitted with A.E.C. 11·3-litre diesel engines. To date, over 1500 engines of this type have been supplied to Canada, in addition to hundreds of other types. Production of the buses will begin immediately at the Can-Car plant at Fort William, Ontario, and deliveries are expected to be complete by the autumn. The Canadian Car Company have for many years been A.C.V.'s sole distributors in Canada, and all the buses they manufacture are fitted with A.E.C. engines.

A Heenan torque-reactor stand is to be supplied by **Heenan & Froude Limited,** of Worcester, to Pakistan International Airlines, at Karachi Airport. The plant, which will be supplied with all accessories and installed under the supervision of the makers, will be used initially for testing Rolls-Royce " Dart " engines after overhaul and will be at 7000 bhp, to meet possible future requirements.

A cable-suspended hangar stand, supplied by the same company to Air India International for testing piston-type aircraft engines, is now in operation at Santa Cruz airport, Bombay.

An order for twenty R4AUU8 generating sets for the Government of Argentina has been received by **The National Gas & Oil Company Limited,** of Ashton-under-Lyne. These sets consist of National diesel engines, coupled to alternators and switchgear made by the **Brush Electrical Engineering Company Limited,** of Loughborough, and will be largely used to provide emergency power in small townships.

Sixteen of these sets, all of which will be delivered this year, will be of the semi-transportable type, with the engine, alternator, switchgear, etc., mounted on a skid-

VULCASCOT *ANTI-VIBRATION PADS*

The **OIL RESISTING**
Machine Mountings
Tested and proved
by years of usage

IMPROVE
PRODUCTION

Check vibration, shock & noise
Make machine installations easy
No fixing bolts required
Save maintenance time and cost
Combat nervous strain
Isolate loads up to 4 tons per sq. ft.
Standard sizes : 18 in. × 18 in. × ⅛"
and 36in. × 18 in. × ⅛"

Manufactured by;—
VULCASCOT (Gt. Britain) LTD.
87-99 ABBEY ROAD, LONDON, N.W.8

Tel: MAida Vale 7374/5 *Grams:* VULCASCOT, LONDON NW8

PROSPECTING FOR PLANT AND MACHINERY?

Here's a mine of information on the subject!

Send now for a current copy of The Albion Machinery Catalogue—a comprehensive stock list of new and second-hand Plant and Machinery including Machine Tools, Contractors' Plant, Generating Sets and Pumps. It is brought up-to-date and reprinted at regular intervals.

SERVING INDUSTRY AROUND THE WORLD **THOS. W. WARD LTD**

Dept: E. ALBION WORKS · SHEFFIELD · ENGLAND.

London Office: BRETTENHAM HOUSE · LANCASTER PLACE · STRAND · LONDON W.C.2. GP/58

type underbase. Each of these sets will be capable of developing 554 kW at 750 rpm. The remaining four sets will be of the transportable type, each set being capable of developing 500 kW at 750 rpm. These four sets will be mounted on a skid-type underbase, which will be secured to an independent trailer, complete with pneumatic tyres and sheet-steel panelled canopy fixed to a steel framework with side flaps. By a slight modification of the cooling arrangement, the complete set mounted on the underbase can be lifted from the trailer and put into service as a semi-transportable unit.

A contract, amounting to approximately £500,000, for the supply of specialized electronic equipment for the Defence Forces of the Federal Republic of Germany has been received by **Decca Radar Limited,** of London, S.W.9. Equipment based on Decca's developments in this field is also being supplied for the defence and civil requirements of other countries.

Despite competition from a number of foreign competitors, **Standard Telephones and Cables Limited,** of London, W.C.2, has been awarded a £250,000 contract from the Federal Power Board of Rhodesia and Nyasaland for the manufacture and installation of remote-control equipment for the Kariba hydro-electric scheme on the Zambesi river. This equipment is an integral part of the control system which will link Kariba with existing thermal power stations in the Central African Federation. When completed, Kariba (with an initial capacity of 500 MW and an ultimate capacity of 1200 MW) will be the largest power station in Africa.

An order for two 275-MW steam turbo-alternator sets, with their condensing and feed-heating plant, has been placed with **The English Electric Company Limited** by the Central Electricity Generating Board. The sets, which are for the projected new Blyth "B" power station, are the two largest in-line turbo-alternators of their kind (50 cps) in the world, and the order is stated to be worth more than £5 million.

These sets are of new design, their main advantage being that, although the general arrangement of the Blyth "B" machines will be similar to that of the 200-MW sets at High Marnham power station, it is now possible to obtain an output of 275 MW from a frame size only slightly larger than that of the 200-MW sets.

RECORD PRODUCTION BY THE UNITED STEEL COMPANIES LTD.

Continuing an unbroken run of steel production records for the sixth successive year, The United Steel Companies Limited produced 2,903,809 ingot tons during 1957, an increase of 217,973 tons over the 1956 figure. Pig-iron production was also a record at 1,813,044 tons, compared with 1,524,744 tons in 1956. The installation of a new turbo-blower, hearth enlargement of the Queen Bess blast-furnace, and increased sinter production at Appleby-Frodingham all contributed towards this improved result.

Coke output fell slightly during the year from 1,602,932 tons to 1,586,290 tons, the decline being largely attributable to reduced coke demands during the relining of blast furnaces. Ironstone production from the company's underground and opencast sites in Lincs., Northants., and Rutland and underground mines in Cumberland was higher than ever before at 5,099,663 tons, an increase of 723,139 tons over the 1956 figure.

GIFT TO RUGBY TECHNICAL COLLEGE

Warwickshire Education Committee have announced the receipt of the first instalment of a gift of £25,000 made by the British Thomson-Houston Company to the Rugby College of Technology and Arts, as a part payment of the cost of the Halls of Residence now being erected in the College grounds.

The steady growth in the importance of Rugby College as a centre of technical education has always been accompanied by close co-operation with industry, in which work the BTH Company has played a prominent part. The establishment of sandwich courses for students in the engineering technologies and for which the Halls of Residence are being provided (the first, it is thought, to be built by a Technical College) is a noteworthy landmark in the relations between college and industry.

DEMAND FOR TECHNOLOGISTS IN INDUSTRY

The problem of training and providing an adequate number of technologists for industry is one which is receiving close examination, not only in Britain but also in America and Russia. In the U.K., one of the firms who are endeavouring to provide a comprehensive training scheme is the British Oxygen Group. The Edmonton factories of British Oxygen Engineering Limited and British Oxygen Gases Limited (Equipment Division) now have over 100 apprentices who are receiving training. This is the largest number in the Company's history. The apprenticeship scheme has grown rapidly during the past few years. In 1950, only 15 apprentices were undergoing training courses.

A new training school, opened in September, 1956, is now providing facilities for about 30 boys at present, and three full-time instructors are employed. Training is provided at Edmonton in mechanical, electrical, chemical, and production engineering and in commerce.

According to Mr. R. C. Godfrey, Director and General Manager of British Oxygen Engineering Limited, "It is fully recognized in the B.O.C. Group that the apprentices of to-day are the managers of tomorrow.

"High-level positions are generally within the reach of all lads who are prepared to play their part to the full, and I can assure them that they will receive every support and assistance from the Company.

"I am all in favour of youngsters starting at the bottom and working their way upwards by their own efforts. They must be prepared to give a great deal of their time to technical studies, as well as concentrating on the practical aspects provided by their apprenticeship."

INTERNATIONAL CONGRESS BUILDING AT LYONS

International industrial exhibitions and conferences will be possible in the new International Congress Building being erected at Lyons, which this year celebrates its 2000th anniversary. The structure consists of a conference room with seating for 1500 people, a restaurant for 500, committee rooms with 150 seats (each room equipped with six translation booths), and a projection room; in addition, there are two assembly halls, three small committee rooms with 40 seats, lecture rooms, basement garages for 500 cars, office blocks, printing-works connected with translation booths to enable foreign visitors to receive all information necessary to their work in the minimum of time in a permanent form, ten Press rooms, and a super-cinema which will compete with Cannes for the presentation of international television and film festivals.

BRITISH ELECTRICAL POWER CONVENTION

Electricity and World Progress : Britain's Contribution has been selected as the theme of the tenth British Electrical Power Convention, which will be held at Brighton from June 16 to 20, 1958, under the Presidency of Sir George Nelson, Bt., LL.D., F.C.G.I., D.I.C., M.I.Mech.E., M.I.E.E. As in former years, an electrical exhibition will be held in conjunction with the Convention.

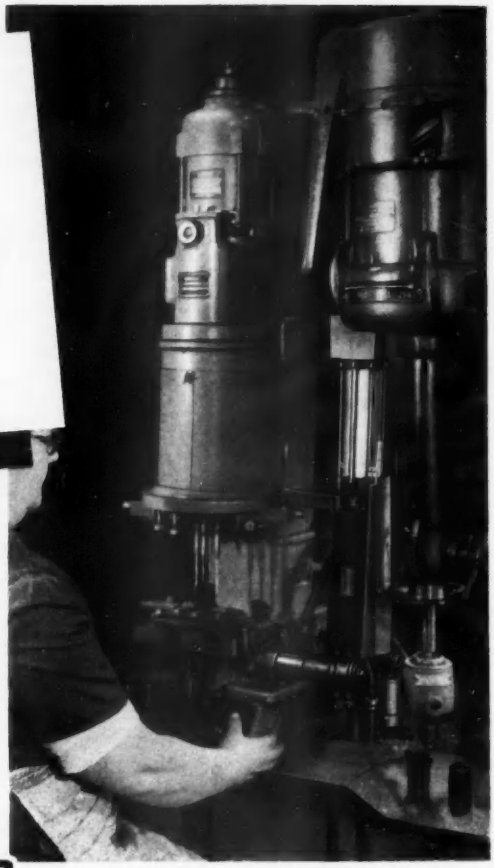
The first session of the Convention will be held in The Dome on the morning of Tuesday, 17th June, when Sir George Nelson will deliver his presidential address. On Tuesday afternoon a paper on *The Development of Nuclear Energy for Electricity Supply in Great Britain* will be presented by Sir Christopher Hinton, K.B.E.,

"DO IT YOURSELF" CASE HISTORIES

No. 101 Special Lampholder.

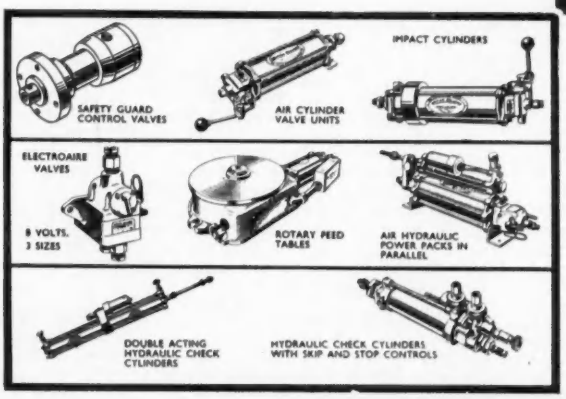
Operation: Drill 4 and Tap 2 holes.
Old Method: 2 separate operations.
Output: 200 per hour.
New Method: Multi driller with British Bellows drill feed unit fitted to standard drilling machine, drills 4 holes while previous moulding is being tapped.

Output: 415 per hour.



Photograph by courtesy of Witton Moulded Insulation Works G.E.C.

A series of advertisements showing ways in which British Bellows Controlled Air Power equipment is helping the wheels of British industry to turn faster. British Bellows equipment can be fitted to new or existing machinery by your own staff, thus cutting out heavy installation costs.


SAFETY GUARD CONTROL VALVES
AIR CYLINDER VALVE UNITS
IMPACT CYLINDERS
ELECTROAIRE VALVES
8 VOLTS. 3 SIZES
ROTARY FEED TABLES
AIR HYDRAULIC POWER PACKS IN PARALLEL
DOUBLE ACTING HYDRAULIC CHECK CYLINDERS
HYDRAULIC CHECK CYLINDERS WITH SKIP AND STOP CONTROLS

The range of British Bellows equipment is wide—far too wide to illustrate here. We invite you to contact us, by letter or telephone ; we shall be delighted to send you comprehensive details of the entire range.

We invite you to visit us on
STAND 324
Mechanical Handling Exhibition
Earls Court, May 7 - 17

BRITISH BELLOWS

CONTROLLED AIR POWER EQUIPMENT

Manufactured & distributed by GEO. H. HUGHES LTD., EDGEMOND AVENUE, BIRMINGHAM, 24.
Telephone : ASHfield 1183.

F.R.S., D.Sc., M.A., M.I.C.E., M.I.Mech.E., M.I.Chem.E., Chairman of the Central Electricity Generating Board.

Wednesday's proceedings will begin with an address on *The Development of Nuclear Energy for Electricity Supply Overseas*, by Sir Claude Gibb, K.B.E., F.R.S., D.Sc., M.E., M.I.Mech.E., chairman and managing director of C. A. Parsons & Co. Ltd. *Britain's Part in Electrical Development Overseas* will be the subject of a paper on Wednesday afternoon by H. J. Beard, M.I.E.E., of Merz and McLellan, consulting engineers.

Attention will be centered on hydro-electric matters and the domestic use of electricity in Thursday's proceedings. *British Hydro-Electric Plant and World Power Requirements* is the title of a paper to be presented by three members of the staff of The English Electric Co. Ltd., i.e., J. C. Beverley, M.A., A.M.I.Mech.E., A.M.I.E.E., E. G. Teasdale, B.A., and A. Wilmot, B.Sc.Tech., D.I.C., A.M.I.Mech.E., who will trace the changes in the magnitude and nature of the demand for hydro-electric powerplant in recent years for both the United Kingdom and the world markets, and deal with the requirements of pumped storage. They will show how British manufacturers have met these demands and will emphasize the ability of British concerns to deal with all aspects of hydro-electric stations.

On Thursday afternoon J. I. Bernard, B.Sc., M.I.E.E., of the British Electrical Development Association, will speak on *The Development of the Electrically Equipped Kitchen*. The popular "Electrical Forum", at which a team of experts answers questions on electrical matters, forms the concluding session of the Convention on Friday morning. This will be followed by the Annual General Meeting, at which officials for 1958/9 will be elected and the venue of the 1959 Convention decided.

MODEL of "ZETA" FOR BRUSSELS EXHIBITION

A model of "ZETA", 7 ft high, in which a representation of the Harwell experiments towards controlling fusion will be given, is to be a highlight of the British Government Pavilion at the Brussels Universal and International Exhibition in April, 1958.

The Brussels model, which will be the first ever to be shown to the public, will be housed in the Technology and Science section of the Pavilion and will be built to one-third scale. Its torus will be made of perspex, so that the interior flash can be seen at 10-sec intervals. The model will be mounted on a platform and so sited that it forms a natural climax to a series of scientific exhibits. Flanking it will be a display of thirty-five British Nobel prize-winners in the field of science.

THE CHEMICAL AND PETROLEUM ENGINEERING EXHIBITION

Sponsored by the British Chemical Plant Manufacturers' Association and the Council of British Manufacturers of Petroleum Equipment, an entirely new trade exhibition, The Chemical and Petroleum Engineering Exhibition, will be held between June 18 and 28, 1958, at Olympia, London.

The growth of the British chemical and petroleum industries is the direct outcome of the policy of refining crude oil in consumer, rather than producer, countries, and for this purpose British plant and equipment have been developed to a truly remarkable degree. The exhibition will therefore be welcomed by those concerned, displaying as it does under one roof convincing evidence of the achievements of exhibitor manufacturers, over 250 of whom have already booked space, amounting ing to more than 125,000 sq ft. Exhibitors will include firms who contract for complete refineries and chemical works, as well as suppliers of process plants for the production of heavy chemicals, fertilizers, explosives, coal-tar products, petrochemicals, fine chemicals, and pharmaceuticals, paints and varnishes, plastics, and a wide range of many other chemicals and chemical products.

A range of oil-field equipment and oil-well machinery will also be shown, and plant for unit operations will be represented by the makers of equipment for size reduction and separation, distillation, solvent recovery, evaporation, centrifuging, etc. Also shown will be important plant items such as heat exchangers, high-temperature heating systems, pumps, valves, instruments, packings and jointings, etc. Plant will also be shown in the more recently developed ferrous and non-ferrous metals and alloys, in stoneware, fused silica, plastics, carbon, and glass. Added attractions for visitors will be a conference on "The Organization of Chemical Engineering Projects", organized by the Institution of Chemical Engineers, and films demonstrating the part played by the chemical plant and petroleum equipment industries in the development of their customer industries.

All enquiries should be addressed to the organizers, F. W. Bridges and Sons Ltd., Grand Buildings, Trafalgar Square, London, W.C.2.

MECHANICAL HANDLING EXHIBITION AND MATERIALS HANDLING CONVENTION

Organized by *Mechanical Handling*, the 1958 Mechanical Handling Exhibition will, together with the Materials Handling Convention, be held at Earls Court, London, from May 7 to 17, 1958, and will constitute the largest display of labour-aiding equipment and methods ever presented in the world.

Occupying about 500,000 sq ft of floor space, the Exhibition will for the first time be international in character, with over 250 exhibitors displaying equipment from Great Britain, America, France, Germany, Italy, and Scandinavia. The number of exhibits will run into thousands and will include the latest conveying and handling devices, cranes, industrial trucks, aerial rope-

TYPROD IN INDUSTRY

ROLLS-ROYCE LIMITED, at their Hillington factory, use TYPROD Matting on their pallets and storage racks to prevent damage to oil engine crankcases and cylinder heads. TYPROD Industrial Matting is also acknowledged ideal for providing a safe non-slip footing at machines and workbenches. TYPROD is hardwearing yet resilient and reduces industrial fatigue. Standard sizes or special lengths to specification.

Photography by courtesy of Messrs. Rolls-Royce Limited.

Exhibiting on Stand B41 Factory Equipment Exhibition

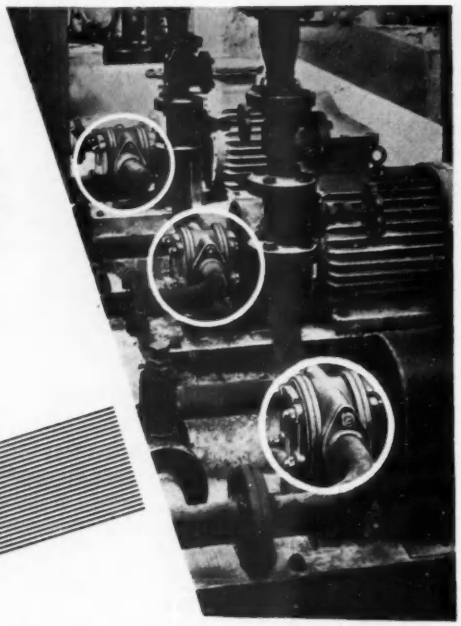
We are always pleased to discuss your special problem.

Write for specimens and details to Dept. ED

TYRE PRODUCTS LTD 503 HARROW ROAD, WEMBLEY, MIDDLESEX PHONE WEMBLEY 5555

DAVID BROWN

ROLOID
REGISTERED
gear pumps



FOR PRESSURES UP TO 300 LB/SQ INCH

These units, available in a comprehensive range of sizes, are compact and easy to install. Typical of their many uses are applications such as hydraulically operated machine tools, hoists, presses, oil fuel pumps and oil lubricating systems.

ROLOID features include :

Uniform discharge — High volumetric Efficiency

High power efficiency — No sliding vanes

Rotors mounted on roller bearings.

Accurately generated teeth ensure continuous oil seal.

Our extended production facilities for these pumps enables us to offer quick delivery and complete details are given in Publication E326.15/f Available on request.

THE
DAVID BROWN
CORPORATION (SALES) LIMITED
GENERAL GEAR DIVISION
PARK WORKS · HUDDERSFIELD

ways, earth-moving equipment, lifting tackle, and all types of equipment and accessories associated with mechanical handling. In addition, extensive use will be made of suitable diagrams, photographs, motion pictures, and working models of complete factory installations. At the Materials Handling Convention, running concurrently, leading authorities will present papers dealing with the latest handling methods in industry.

Full information can be obtained from the Exhibition Manager, Dorset House, Stamford St., London, S.E.1.

USE OF MAINS-FREQUENCY CORELESS INDUCTION FURNACES FOR ALLOY-STEEL PRODUCTION

One of the new Birlec mains-frequency coreless induction furnaces produced by Birlec Limited, of Erdington, Birmingham, is now in use by The Inca Steel Company Limited, of Sheffield, for the regular production of high-speed steels. Similar furnaces are already used in non-ferrous and iron foundries, but this new installation is the first example to be used by a British steelmaker for the production of alloy steel.

The furnace supplied has a capacity of 1½ tons, and a power input of 450 kW can be applied, giving a maximum output of the order of 0·5 ton per hour of prime high-speed steel ingots. Flexible power-input control enables metal temperatures to be closely adjusted. Mounted flush with a working platform about 4 ft above the foundry floor, the furnace is tilted by hydraulic rams, served by a self-contained pressure unit.

BRITISH STANDARDS

(Copies of British Standards may be obtained from the British Standards Institution, 2 Park Street, London, W.1)

Wire Ropes for Cranes and Excavators and General Engineering Purposes (B.S. 302 and 621:1957).

This publication (price 7*s.* 6*d.*) applies to wire ropes previously within the scope of the earlier editions of B.S. 302 and B.S. 621. It covers requirements for steel wire ropes of ordinary lay or Lang's lay from $\frac{1}{16}$ to 2¾ in. diameter in various constructions, i.e., round-strand, flattened-strand Group II F, and multi-strand non-rotating, two tensile ranges being specified for the wire, i.e., 100/110 tsi and 110/120 tsi. Full test requirements are detailed, and data on construction, breaking strengths, and weights are presented in tabular form.

An appendix provides users with guidance on galvanizing, diameters of drums and pulleys, reverse bends, drum and pulley grooves, angle of lead, factor of safety, splicing, terminal fittings, storage, uncoiling and handling, installation, and maintenance. This guidance is followed by lists of information to be provided by purchasers and suppliers, and by illustrations of cross-sections of typical ropes.

Wire Brushes (B.S. 2939:1958).

Hand and rotary brushes filled with wire are the subject of this new British Standard (price 7*s.* 6*d.*), which has been prepared by representatives of the wire-brush industry, local authorities and hospitals, Government departments, and the Services.

The new specification deals with wire scratch brushes, casting brushes, platers' brushes, scrubs, brooms, rotary cup brushes, and with a wide range of types for the removal of carbon, scale, paint, etc. from metal surfaces (when mounted on portable pneumatic or electric tools and on stationary grinders). Many of these brushes were originally dealt with in War Office Specification No. TG. 26 and, while the British Standard may thus be regarded as superseding TG. 26, it includes, at the request of the manufacturers, many brushes not previously standardized. With certain limitations, the Committee has framed the requirements in terms which will include hand-drawn and machine-made brushes, in order that the standard can be applicable to the whole output of the wire-brush industry.

Classified Advertisements

The rate for all classified advertisements is 9d. per word : in bold print 1s. per word : minimum order 10s. Box-number advertisements 1s. extra. Instructions, together with remittance, must be received not later than the 1st of each month for advertisements to appear in the same month's issue.

OSMOND

CUTTING OFF MACHINES

A. & S. OSMOND, LTD.
13 DOWRY SQ., BRISTOL

Telephone :
Bristol 27604

NEW BALL & ROLLER BEARINGS

OVER 4,000,000 IN STOCK
IN MORE THAN 4,000 TYPES

BRITAIN'S LARGEST STOCKS

WRITE FOR NEW STOCK LIST

CLAUDE RYE BEARINGS

895–921 FULHAM ROAD, LONDON, S.W.6
Renown 6174 (Ext. 24) Cables: Rybearings, London Telex 23453

The Specialist Foundry
with own machine shop
for

BLACKHEART MALLEABLE IRON CASTINGS

•

HEAT & ABRASION RESISTING ALLOY CASTINGS

•

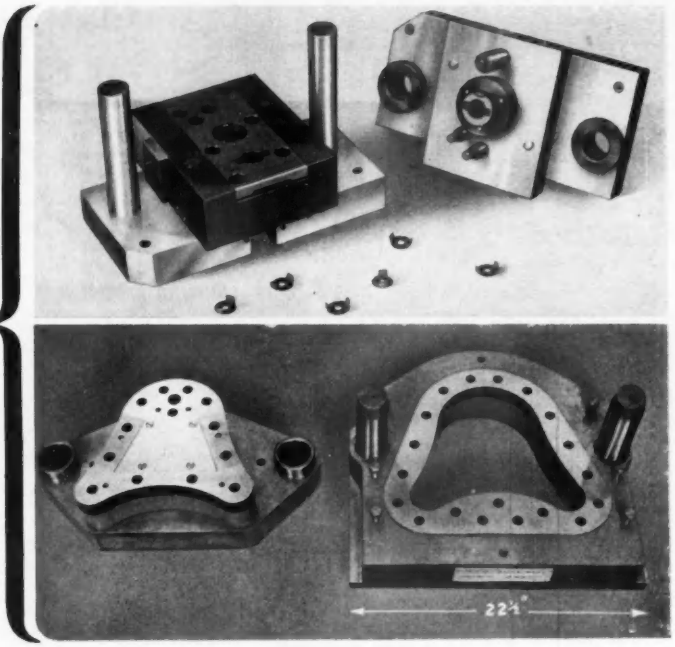
Manufacturers of

"PULMAC" PULVERISING MILLS

Follsain-Wycliffe Foundries Limited

LUTTERWORTH, NR. RUGBY Tel. 10, 60 & 152

476



BECAUSE of its high chromium and carbon content, 476 Steel resists wear and is specially suited for exacting punching and forming operations on abrasive materials. It has also considerable toughness, the tool edges standing up to shock applications, such as heavy punching and shearing. The photographs illustrate two contrasting applications. (Top) Three stage press tool for punching and forming clamping washers from brass strip (courtesy, Clarke Chapman & Co. Ltd.). (Bottom) Heavy press tool for blanking hoist bracket in $\frac{1}{8}$ in. thick mild steel (courtesy, Stothert & Pitt Ltd.). 476 is air hardening and machinable in the annealed condition. Applications include blanking dies and punches for sheet brass, copper, zinc, high silicon transformer steels and hard abrasive materials generally ; blanking tools for steel sheet and plate ; blades for flying strip shears and plate shears ; deep drawing dies, cupping dies, forming dies ; sheet metal forming rolls ; circular cutters for strip ; trimmer dies, thread rolling dies ; gauges and other precision tools ; taps, staybolt taps ; brick mould liners ; master hobs for cold hobbing plastic moulds ; cut moulds for plastics.

SANDERSON'S

SANDERSON BROTHERS AND NEWBOULD LIMITED

Attercliffe Steelworks, P.O. Box 6, Newhall Road, Sheffield 9

ESTABLISHED 1776

NEW TECHNICAL BOOKS

Semiconductor Thermoelements and Thermoelectric Cooling. By A. F. Ioffe. Translated from the Russian by A. Gelbtuch. 190 pp., 83 illustrations. Publishers : Infosearch Limited, 16 Ladbroke Gardens, London, W.11. Price 42/–.

Mainly intended for physicists, as well as electrical, refrigeration, and air-conditioning engineers, and as an aid to designers, this excellent book is divided into two parts. The first part covers the theory of thermoelectric phenomena, the requirements which must be satisfied by materials, and various practical applications, including the generation of electricity, cooling, heating, sound generation, and zone-melting by the Peltier effect, together with examples of thermoelectric devices manufactured in Russia.

The second part of the book is concerned with the theory, design calculations, and construction of domestic thermoelectric refrigerators, micro-coolers, and thermostats for use in electronic equipment, instruments, and medical apparatus.

The information presented was originally published in Russia at the end of 1956, but has since been revised and brought up to date for this English edition by Professor Ioffe, who is at present Director of the Institute for Semiconductors of the U.S.S.R. Academy of Sciences.

Introduction to Heat Transfer. Third Edition. By Aubrey I. Brown and Salvatore M. Marco. 348 pp., 82 illustrations. Publishers : McGraw-Hill Publishing Company Ltd., 95 Farringdon Street, London, E.C.4. Price : 52/6.

Presenting the fundamentals of heat transfer in a readily understood manner, Professors Brown and Marco provide a clear understanding of the principles of the subject, with a working knowledge of the application of these principles to a variety of engineering problems and with a good foundation for advanced and more specialized studies in this field.

In this third edition, coverage has been enlarged and the material brought completely up to date, while symbols and notation have been revised in keeping with the general adoption of American Standards. Two new chapters have been added. One of these is on fluid flow in the convection process, which will be a suitable background for those who have not had a separate course in fluid mechanics and which will serve as a review for others. The other chapter covers graphical and numerical methods for heat-conduction problems and provides information on methods of solution that are receiving increasing attention. There is also new material on fundamental units, intended to overcome difficulties which students have sometimes encountered because of confusion of force and mass units. In addition, a new section on the design of electrical transformers has been included.

Advanced Pattern Making. By L. L. Cox. 230 pp., 258 illustrations. Publishers : The Technical Press Ltd., 1 Justice Walk, Chelsea, London, S.W.3. Price : 45/–.

Well-produced and illustrated, this excellent book deals, at an advanced level, with the technique of pattern-making in wood for foundrymen and engineers, and, at a more elementary level, with the allied problems of pattern-making in metal. Most of the subjects discussed are included in the syllabus for the Final Examination in Pattern-Making set by the City and Guilds of London Institute, and should be of special use to those taking this examination or following similar courses of study elsewhere.

Several recent developments in technique are also discussed in this book. Among these are the production and use of patterns and core boxes made of plastic materials—a technique which has only recently been developed to a satisfactory stage for foundry use.

Man and Automation. By L. Landon Goodman. 296 pp., 23 illustrations. Publishers : Penguin Books Ltd., Harmondsworth, Middlesex. Price : 3/6.

As the author points out, the loose use of the word " automation " has caused some confused thinking and writing on the subject, resulting in difficulties in labour relations, management, and other spheres of industrial activity. This excellent book will undoubtedly do much to clarify the subject of automation and to put its aspects and implications into their proper perspective.

Mr. Landon, who is an Associate Member of the Institutions of Mechanical, Electrical, and Production Engineers, a Fellow of the Royal Society of Arts, and a member of the American Materials Handling Society, is well-qualified to deal with this subject. What is more to the point, however, is that he is able to write about it in a clear and simple style, which should appeal not only to the non-technical reader but also to the specialist.

The book, suitably illustrated and provided with an unusually comprehensive index, has been divided into two parts, one covering the technical aspects of automation and its applications in engineering and industry generally, and the other its social, economic, and other aspects, with special regard to its impact on labour and management, trade unions, and technological education, and its human implications.

Penguin Books Ltd. are to be congratulated on the publication of this new " Pelican " book, enabling, as it does, the layman to obtain at a negligible price vital information on a subject which must, in the very near future, be of the greatest concern to all of us.

Kempe's Engineers Year-Book, 1958. 63rd Edition. Edited by C. E. Prockter, M.I.E.E., M.I.Mech.E., under the direction of B. W. Pendred, M.I Mech E., M.I.S.I. 3000 pages. Publishers : Morgan Brothers (Publishers) Ltd., 28 Essex Street, London, W.C.2. Price : (Two volumes in case) 82/6 (postage 2/6).

As always, this well-known reference book covers practically every branch of engineering and provides the answers to innumerable queries in its 79 chapters.

In this new edition, the subject matter has again been brought up to date, additions having been made to various chapters, including those on " Welding and Cutting ", " Water Engineering ", " Iron and Steel ", Non-Ferrous Metals and Alloys ", " Foundry Practice ", " Grinding Abrasives, etc. ", " Machine Tools ", " Wire Ropes ", " Harbours and Docks ", " Railway Engineering ", " Aerodynamics ", " Aircraft Propulsion ", " Electronic Engineering ", " Atomic Power ", " Heating Ventilation, and Air Conditioning," " Public Health Engineering ", and " Concrete and Reinforced Concrete ". Other chapters have been revised, where necessary.

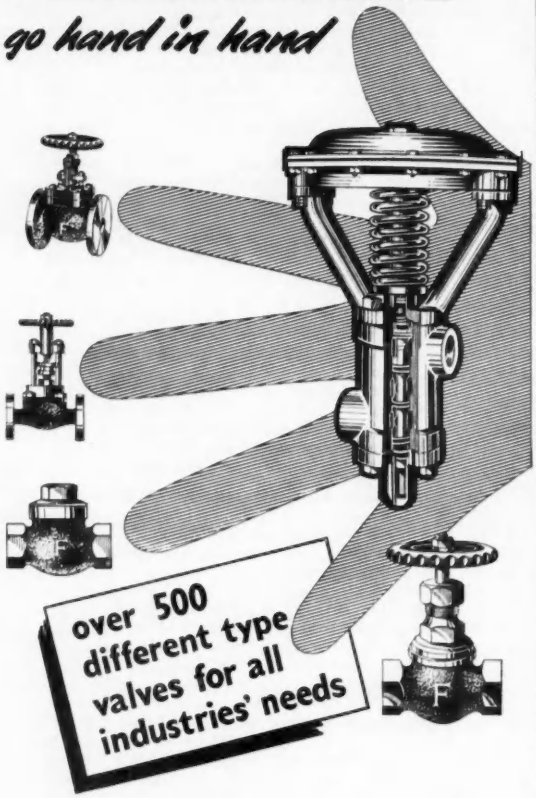
Ideas, Inventions, and Patents. By Robert A. Buckles. 286 pp., 45 illustrations. Publishers : John Wiley & Sons, Inc., New York, and Chapman & Hall, Limited, 37 Essex Street, London, W.C.2. Price : 48/–.

Providing an authoritative source of information, particularly of American practice, in connection with training programmes in chemical and engineering firms, and giving employees of such firms, as well as inventors and business-men in general, a new and interesting insight into the world of patents, this concisely written book answers many questions related to patent law, without the use of irritating legal jargon.

The author discusses the principles underlying patents in all fields of mechanical, electrical, chemical, and nuclear technology, and then gives lucid examples of specific applications in each field. In addition, he illustrates the complete case-history of a simple invention, providing a valuable guide for those who have had no previous experience with the Patent Office or with patent attorneys. Another useful feature is the inclusion of representative forms, etc. connected with patents and a glossary of common patent terms.

RELIABILITY AND PERFORMANCE

go hand in hand



The name's the thing when quality goes with it. Tight glands, tight seats and long life is Our name for quality, as you'll discover when you use our valves. *From 18" valves for steam to $\frac{1}{8}$" valves for air—manual operated or automatic, you can be sure to find a valve to meet your specification in our latest range.*

insist on

HUNT & MITTON LTD

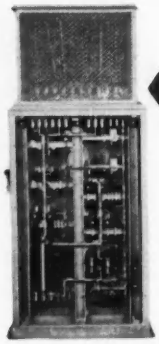
Quality **VALVES**

Write to-day for details:
HUNT & MITTON LTD., OOZELLS ST. NORTH, BIRMINGHAM 1

GWB

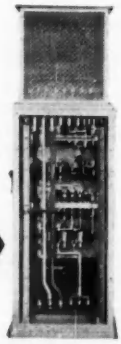
Stator-Rotor Starters

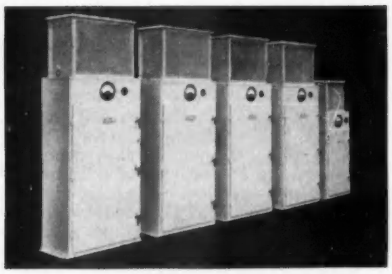
In addition to special purpose single and multi-compartment centralized control panels, G.W.B. design and supply Stator-Rotor Starter panels to any required specification. All contactors and ancillaries can be maintained or replaced from the front; starters enclosed in dust and damp-proof cubicles; unbreakable, rustless 3-phase Star-connected starting resistance either enclosed or in ventilated compartment; adjustable timing control relay, overloads, etc., in accordance with BSS 587 and 775. G.W.B. engineers are available for the solution of all circuit problems and special operation requirements. Sales and service staff are situated at convenient points throughout the country.



Panel supplied to a large rubber manufacturing firm, to control a 45 H.P. motor for Side-wall Buffing Extraction Process.

Panel supplied to another rubber manufacturer for controlling a 30 H.P. Slip-ring Induction Motor in a laboratory mill.





Panels supplied to Lancashire Dynamo & Crypto Ltd. The four large panels each govern a 67 H.P. motor, the smaller panel a 20 H.P. motor.

All contactors are made to the famous G.W.B. standards. Among the many refinements making them pre-eminent in their field are:

- **Sintered Tungsten-Silver contacts for LONG LIFE.**
- **Open type construction for EASY MAINTENANCE.**
- **Special coil design giving LOW CURRENT ABSORPTION.**

G.W.B. Low Tension control gear 10-1400 amps A.C. and D.C.

G.W.B. FURNACES LTD

Control Gear Division
Telephone No.: DUDLEY 4284/5/6/7 & 5081/2/3/4/5
Telegrams: GIBWILDBAR, DUDLEY

P.O. BOX 4, DIBDALE WORKS, DUDLEY, WORCS

Proprietors: Gibbons Bros. Ltd. & Wild-Barfield Electric Furnaces Ltd.
G.W.B. 409

LATEST INDUSTRIAL LITERATURE

1. Centrifugal Fans. A 32-page illustrated brochure contains considerable information and data of great value to all potential industrial fan users and engineers concerned with air-movement problems. Because of their low noise level, the centrifugal fans described are ideal for air-conditioning, plenum heating, and general ventilation duties. By retaining the non-overloading characteristic of the backward curved fan, they are widely used for forced- and induced-draught installations on boilers and furnaces. High efficiency and low running costs make them particularly suited to applications where high pressures are required and, with the self-cleaning action of the blades, eminently suitable for dust-handling duties. The range includes a fan for most air-movement duties, and protective treatments can be applied or special materials used in construction to provide a suitable unit for high-temperature or corrosive-fume applications. Some illustrated applications of the fans in dust-control systems are included.

2. Hydrostatic Chucks. Details are described in a 6-page brochure of a range of hydrostatic chucks designed for the maintenance, during grinding and other machining operations, of extremely close limits with super-finish on hydraulic and other components. By contrast with diaphragm chucks, these chucks need no additional control equipment and can easily and speedily be removed from one machine and fitted to another by means of simple adapters. Where it is desired to replace other types of chuck by this chuck, existing spindle push-rod gear can be utilized with the minimum of disturbance. These hydrostatic chucks are very versatile in use and adaptable to many types of machine for holding all types of precision parts.

3. Special Pig Iron. A new type of pig iron, specially designed to meet the modern requirements of high-quality castings, is described in an attractively presented 12-page brochure. Castings made with this material are close-grained, grey in all sections, have very good physical properties, and can be machined at high speeds. Some of the outstanding features of this pig iron are speedier machining, reduction of piece-work prices on machining, reduction of tool wear and setting-up times, elimination of annealing costs, solution of the problem of changes and chilling, elimination of expensive ladle inoculation, improvement in tensile strengths without expensive alloys, and reduction in scrap casting percentage.

4. Compound Clamping Tool. Providing an absolutely safe and simple method of clamping workpieces from ⅜ in. in height and upwards, the new compound clamping tool described in a leaflet is a complete unit in itself, designed to exert simultaneously a horizontal and vertical pressure. By virtue of a double-cam action, in conjunction with an angular slot, an enormous clamping pressure is achieved.

Other advantages of this tool include the absence of protruding nuts or screws, rapid setting without the use of packing pieces, impossibility of accidents caused by slipping, non-corrosive finish, and easily controllable amount of pressure for final machining, thereby achieving higher accuracy.

5. Hydraulic Packings. Complete details of the functions and uses, in both hydraulic and pneumatic equipment, of a comprehensive range of hydraulic packings, including "O" rings, "U" packings, distributor seals, and cup and hat packings, are given in a well-produced 56-page brochure. Various designs are available, each having its own inherent special advantages and preferred uses. To facilitate selection of the best hydraulic packing for any specific application, a summary for general guidance is included. In addition, information is given on such questions as storage, installation, etc.

6. Safety Steps. An illustrated 4-page leaflet describes details of safety steps recommended by insurance companies, factory inspectors, and safety officers. These steps are of all-welded tubular steel construction, reinforced for maximum strength, unlimited wear, and great stability. Easy movement is possible on four swivel, ball-bearing castors, provided with thread guards, which will also prevent dust and dirt clogging up the axles and bearings. The castors retract when the user mounts the steps, locking the structure safely to the floor on four rubber-tipped feet. When stepping off, the castors return to their original mobile position. The user also has both hands free for work and no carrying is necessary, as, in their mobile position, the steps move at the slightest touch.

7. 19½ in.-Stroke Shaping Machine. An illustrated description and specification of a robust 19½ in.-stroke shaping machine incorporating many recent improvements are given in a 6-page leaflet. Particularly noteworthy is a range of special attachments which greatly increase the versatility of the model, including indexing attachments for gear cutting and spur-gear and bevel-gear generating attachments.

8. Strippable Protective Coatings. Particulars are given in a neatly produced 4-page brochure of a transparent, strippable protective coating for the simple, safe, and economical packaging of components, gears, tools, precision instruments, etc. The coating takes the form of a film which is tough, yet flexible, and provides complete protection against moisture, oxidation, abrasion, and rough handling, while its feature of complete transparency permits easy inspection and identification of the article to be protected.

The coating is easily applied by hot-dipping in suitable melting pots, and the article can then be packed and despatched almost immediately after immersion. When required, the film can be peeled off quickly.

9. Conveyors. The individual features of different models of gravity and power conveyors are outlined in an illustrated 8-page brochure. These conveyor units are built to fit many industrial applications, and their portability and all-purpose design make it easy to move them from job to job, though they may be combined into a full-scale flow system to move production in the largest plant.

Full specifications of each conveyor model described are included, and, in addition, typical applications are clearly presented.

10. High-Quality Steels. In a well-compiled and lavishly illustrated 56-page brochure, neatly and conveniently bound in a loose-leaf cover, details and specifications are given of a comprehensive range of high-quality steels, including free-cutting steels, case-hardening steels, high-tensile fast-machining high-impact steels, bright cold-rolled mild-steel strip, deep-drawing steels, special steels for press-work, and bright-steel bar and strip. In addition, numerous useful tables, including hardness conversion tables, load equivalents, gauge comparisons, weights of bars and strip, etc., are appended.

MAIL THIS COUPON TO-DAY

THE ENGINEERS' DIGEST, 3.58
120 Wigmore Street, London, W.1.

Date.....

Please send free and without obligation the literature indicated by the following circled numbers:

1 2 3 4 5 6 7 8 9 10

Name .....

Position .....

Company.....

Address .....

PRESSINGS

If you require pressings consult Ward (Metal Details) Ltd. We are specialists in the manufacture of all types of small and medium pressings of any shape, size and thickness, in steel, tinplate, copper etc. from which complete assemblies can be fabricated by welding, soldering or brazing.
Illustrated here are some examples of our products, and similar components can be produced to your own specification and design, and supplied in painted, plated or enamelled finishes.

WARD
(METAL DETAILS) LTD.

DARLASTON · STAFFS

STAINLESS STEEL
SHEETS AND BARS

Why burden yourself with large stocks

go to **CASHMORES**

for 'off-the-shelf' delivery

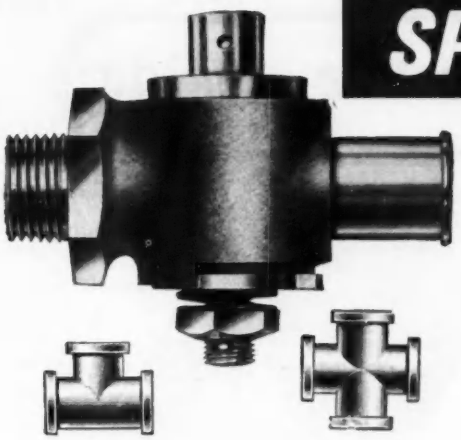
BRITISH MATERIAL ONLY

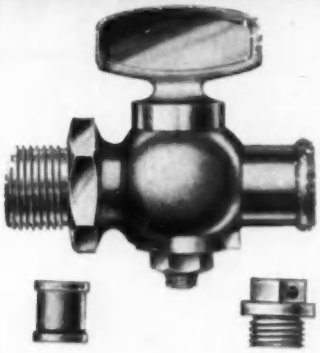
One of the largest STAINLESS STEEL STOCKHOLDERS in the country.
COMPETETIVE PRICES · SEND FOR STOCK LIST

JOHN CASHMORE LTD
GT. BRIDGE · TIPTON · STAFFS. *Tel. Tipton 2181/7*

SM/JC3099

SPECIAL COCKS...





Wm. Whitehouse
& CO. LTD.

EMPIRE WORKS,
BRUETON STREET, BIRMINGHAM 4.
Telephone: ASTon CROSS 2451.
Telegrams: "EMPIRE PHONE" BIRMINGHAM.

for the Engineering and Motor Trades suitable for heating and lubricating systems.
Our designers and technicians are at your service in the development of new ideas. Why not call in our special representative.
We are noted for the quality and range of standard brass work—a catalogue will be sent on request.

"Thermindex" Paints are temperature sensitive compounds which indicate by a sharp, clear cut change of colour when the temperature of a surface has attained or exceeded a predetermined value, so that information on the temperature of an entire surface is given at a glance.

Write Dept. KL/6 for full technical details.

"THERMINDEX"
TEMPERATURE INDICATING PAINTS

SOLE DISTRIBUTORS FOR EUROPE AND THE U.K.

J. M. STEEL & CO. LTD.
36-38 KINGSWAY, LONDON, W.C.2
Tel.: HOLborn 2532/5

Branch Offices

51 SOUTH KING ST., MANCHESTER 2
Tel.: Deansgate 6077/9

45 NEWHALL ST., BIRMINGHAM 3
Tel.: Central 6342/3

Manufactured by Synthetic & Industrial Finishes Ltd.

STEAM TRAPS
GUARANTEED FOR 2 YEARS

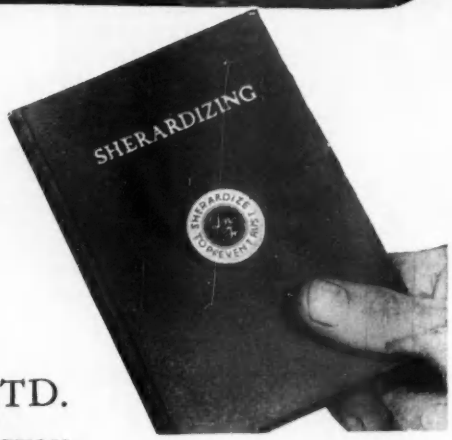
ALSO REDUCING VALVES, WATER HEATER CONTROLS, H.P. HOT WATER VALVES

MIDLAND INDUSTRIES LIMITED
HEATH TOWN WORKS WOLVERHAMPTON Phone 23901

YOURS *for the Asking*

LEARN HOW TO:—
SPECIFY,
TEST,
USE,

SHERARDIZING



ZINC ALLOY
RUST-PROOFING CO. LTD.

SHAKESPEARE STREET, WOLVERHAMPTON

TELEPHONE: WOLVERHAMPTON 20647/8/9

ALSO AT LONDON & ROCHDALE

For increased efficiency...

Flexello
put it on Castors

'Putting it on castors' is certainly the way to speed things up, and to an amazing extent when the right castors are used for the job. The varied uses of Flexello castors are virtually limitless. They are used in nurseries and steel mills, aircraft plants and beauty parlours. Flexello has the range, the service and facilities to make castors the true servant of the production manager, the hospital matron, the restaurant manager or the storekeeper. Closest inspection, superior design and up-to-date production methods have made Flexello the largest castor manufacturer in Europe.

Only a very small section of our range is shown here. Please send for catalogue No. 156 ED or a technical representative for industrial advice.

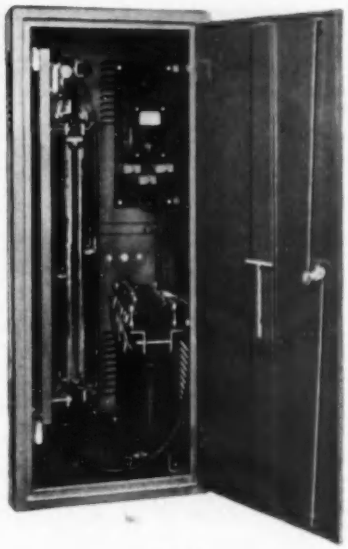
Flexello

CONSTANT QUALITY
CASTORS

FLEXELLO CASTORS & WHEELS LTD., SLOUGH, BUCKS. Tel: SLOUGH 24121

Voltage Fluctuations affecting your processes?

Consistent supply voltage is essential to industry for manufacturing processes and to extend the life of important electrical plant.
B.P.T. automatic voltage regulators eliminate all variations in supply voltage, regardless of variations in frequency, load and load power factor.



See us at the Shows

- Electrical Engineers Exhibition (A.S.E.E. Ltd.) March 25th/29th **Stand No. H.22**
- R.E.C.M.F. Exhibition April 14th/17th **Stand No. 75**
- I.E.A. Exhibition April 16th/25th **Stand No. 943**

BRITISH POWER

BRITISH POWER TRANSFORMER CO. LTD.
QUEENSWAY · ENFIELD · MIDDLESEX
Telephone: HOWard 2411 *Telegrams: Vitrohm, Enfield*

28 Standard Models for Industrial Power Supplies. Quick Delivery.
Write now for our List 606.

Insuloid **Type NX, X & CY CABLE CLIPS**
are
QUICKER, SIMPLER, SAFER

These non-metallic, high-dielectric cable clips provide the safest means of securing cable looms and components in all radio and electrical equipment. They are manufactured in both nylon and P.V.C. in an extensive range covering all wiring requirements. Specially designed radiused edges, non-chafing, anti-corrosive. Fully tropical. Approved all services.

the quick Fix BUSH

Saves time and money
Non-metallic. Fully Tropical.
Here is a Bush designed for instant assembly by a simple snap on finger action. Completely secure under all working conditions.
High Dielectric. Approved all Services.
Samples and literature available on request.

INSULOID MANUFACTURING CO. LTD.
Sharston Works, Leestone Ave., Wythenshawe, Manchester.
Tel: Wythenshawe 2842 and 3163

TO INDICATE CONTROL OR RECORD
TEMPERATURE

For accuracy, ease of reading, robustness, economy and long, trouble free life install Rototherm Thermometers, Controllers and Recorders. Specialists in bi-metallic applications. Visit Stand No. 932, Instruments, Electronics & Automation Exhibition, Olympia, 16th—25th April 1958

Rototherm

BI-METAL MERCURY-IN-STEEL VAPOUR PRESSURE
THE BRITISH ROTOTHERM CO. LTD.
Merton Abbey, London, S.W.19 LIBerty 7661
Midland Factory: Hollis Street, New Basford Nottingham 77847

WHITTLE
Laminated
V-BELT
DRIVES

Patented construction gives great flexibility. Readily adjustable to any length. Belts made in all sizes either 28° or 40° angle

Also makers of
WHITTLE
LEATHER LINK - V BELTS

T. WHITTLE & SONS LTD.
POWER TRANSMISSION ENGINEERS
HEAD OFFICE AND WORKS: WARRINGTON
PHONE: WARRINGTON 3361 (3 LINES) GRAMS: BELT, WARRINGTON
LONDON OFFICE: BUCKINGHAM HOUSE, 19-21 PALACE ST., S.W.1
TEL. TATE GALLERY 9611

TW.14

Between you and me, what we need is a
KOLOK
POSITIVE LOCK WASHER

You'll have no more worries about nuts and bolts working loose if you fit KOLOK positive lock washers. Available in all sizes.

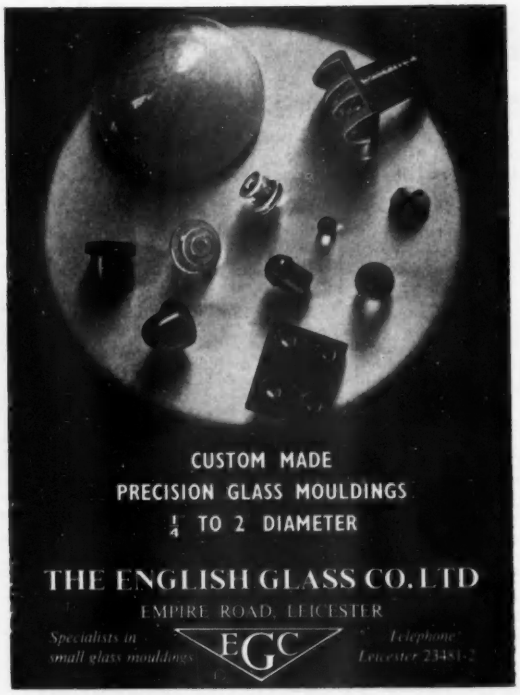
POSITIVE LOCK WASHER CO. LTD.
45 RENFREW STREET, GLASGOW, C.2.
Telephone: DOUglas 9292

If it doesn't–*it can't be*

it can't be a genuine *Jubilee* **CLIP**
REGD. TRADE MARK

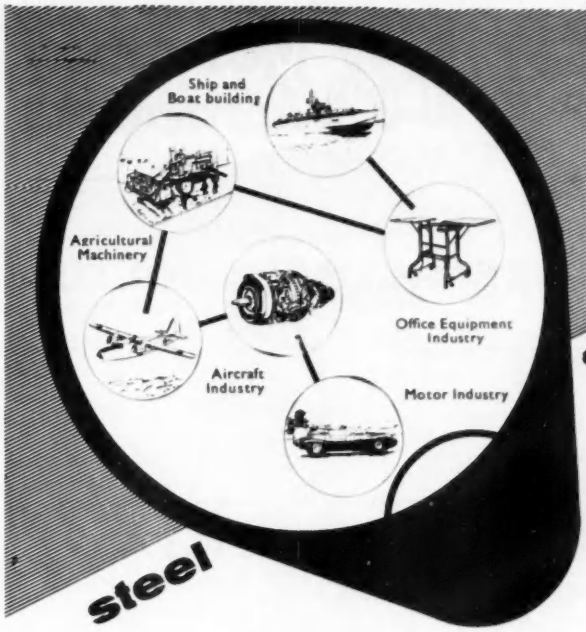
Famous in Four Reigns

L. ROBINSON & CO. (GILLINGHAM) LTD.
LONDON CHAMBERS, GILLINGHAM, KENT. PHONE 5282



CUSTOM MADE
PRECISION GLASS MOULDINGS
¼ TO 2 DIAMETER

THE ENGLISH GLASS CO. LTD
EMPIRE ROAD, LEICESTER
Specialists in small glass mouldings
EGC
Telephone Leicester 23481-2



tubes in industry

Every industry benefits from the use of seamless steel tubing made by REYNOLDS—plain tubing, manipulated tubing, or tubular assemblies—to make stronger, lighter, and more efficient products. If you have not already discovered the advantages of seamless steel tubing, write to REYNOLDS today for information.

REYNOLDS
STEEL TUBING

E6 REYNOLDS TUBE CO. LTD · TYSELEY · BIRMINGHAM 11

ALLOY STEELS
—too ! !

For many years it has been known that ·40/50% Carbon Steel Gears will give an appreciably longer life when Flame Hardened—in fact four to five times the normal.

Fewer people are aware that Alloy Steels—Nickel Chromium—En 23, En 24, En 110, etc., can be similarly treated . . . . and pass the most stringent tests.

Write us or 'phone for full information.

FLAME HARDENERS LTD.
Shorter Works, Bailey Lane, Sheffield, 1
Tel.: 21627

ELECTRIC R.P.M. INDICATORS
up to 8" diameter

WYNSTRUMENTS LTD.
Staverton Aerodrome, Gloucester
Tel: Churchdown 3264 (3 lines).

FOR ALL INDUSTRIAL PURPOSES

T&K KIRKHAM Mechanical Lubricators

From One Feed to Twenty

Fitted on Main and Auxiliary Engines of over 2000 ships

used by all leading British and many Continental Engine Builders

J. & W. KIRKHAM LTD. BOLTON

PHONE: 8027-8 GRAMS: BRASS

PAREX Centres

ESTABLISHED 1923

TUNGSTEN CARBIDE INSERTED

They are Tough and Hard and outlast many H.S Steel or "Live" Centres. "PAREX" means accuracy with economy. They are supplied in all standard tapers, or special for light or heavy duty lathes and grinding machines. "PAREX" metal is not affected by ordinary abrasive grits. Send for price lists and literature to Sole Makers:

ERNEST TURNER & Co. (SALFORD) LTD.

"Parex" Works, West Burton Street, Salford, 5.
Tel. Tra. Park 1381.

inside or outside . . .

UNIVERSAL

Conveyors

KEEP THINGS MOVING

Free illustrated Catalogues are available on request.

UNIVERSAL CONVEYOR CO LTD BARKBY ROAD LEICESTER
Phone: Leicester 67822/3

The Increasing Importance of

EUROPE to BRITISH INDUSTRY

is reflected in the increasing number of British engineering firms exhibiting at European Trade Fairs.

To support these efforts of British Industry **"The Engineers' Digest"** will be represented in 1958 at the Fairs in

BRUSSELS, HANOVER and MILAN

for **VARIABLE SPEED DRIVES** specify **BRAMMER**

WIN - BELT

. . . and minimise loss of production caused by breakdown and costly dismantling of machinery for replacement belts.

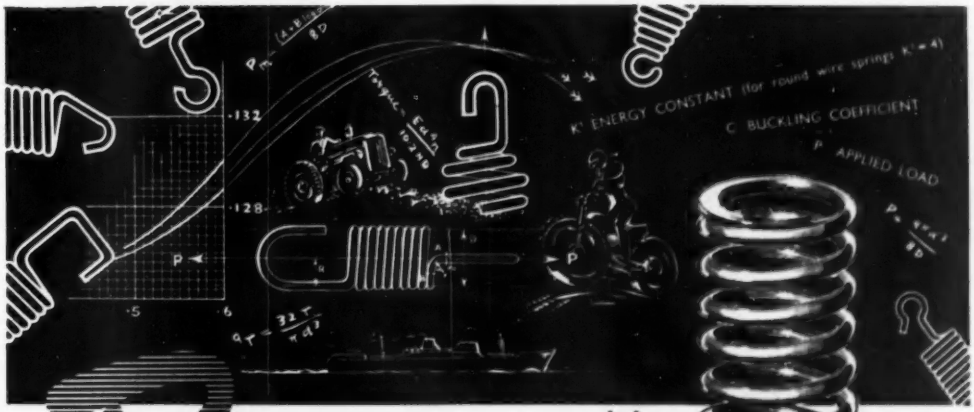
BRAMMER TWIN-BELT can be fitted without dismantling and will give longer life! Greater flexibility, resistance to compression, wear, skidding, heat and oil, make BRAMMER the most versatile variable speed belt. Any length of belt can be made from stock coil.

'Cheapest in the long run' is the hard won fact with

BRAMMER

High Compressive Strength combined with flexibility

H. BRAMMER & CO. LTD.
HUDSON ROAD, LEEDS 9



Ratcliffe SPRINGS

F. S. RATCLIFFE (ROCHDALE) LIMITED.
CRAWFORD SPRING WORKS • NORMAN ROAD • ROCHDALE

CW 5152

Send for this free booklet to The Walpamur Co. Ltd., Darwen, Lancs. It tells you much about the uses of Epoxy Resin Paints in engineering and industry and can help you to solve your protective and finishing problems.

BY APPOINTMENT
TO HER MAJESTY THE QUEEN MANUFACTURERS OF PAINT

THE WALPAMUR CO LTD
DARWEN & LONDON

Paints, Enamels, Varnishes and Industrial Finishes for every conceivable need

W586

DUBIED

UNIVERSAL TOOL & CUTTER GRINDER

with coolant supply system and dust extraction device

The handy machine for grinding all kinds of small and medium-sized HSS and carbide tools.

This low-priced machine is within the means of even small firms having recognised the importance of correctly ground tools as the basis of any manufacturing process.

Edouard DUBIED & Cie, S.A.
NEUCHATEL/Switzerland
Telegrams: "EDCO" Neuchatel.

Hughes - Johnson use Spearseg for cold cutting NiCrMo

When tough steel has to be cut, Hughes-Johnson Stampings Ltd of Oldbury know they can depend on a Spearseg. For this is to-day's leading segmental saw, made — and serviced — by Spear & Jackson, whose experience in the manufacture of saws spans two hundred years.
If you have a cold-cutting problem, have a word with the Departmental Manager (Tel. Sheffield 20202). He'll be only too pleased to help.

Illustration shows a Spearseg cutting 6" square EN 24 material.

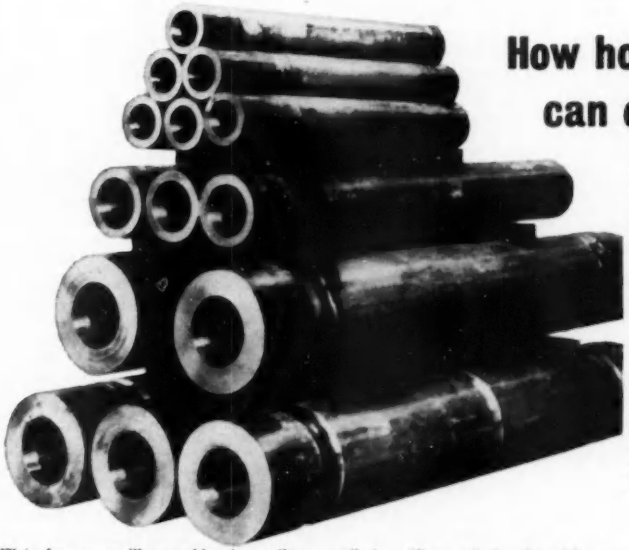
Spearseg

SEGMENTAL SAWS

MADE BY "THE WORLD'S OLDEST SAWMAKERS"

A **SPEAR & JACKSON** PRODUCT MADE AT AETNA WORKS, SAVILE ST., SHEFFIELD 4

OA 4509



How hollow bored bars can cut your costs

All over industry people are finding it's cheaper to use Keetona Hollow Bored Bars for applications covering a very wide field. Keetons specialise in supplying Hollow Bored Bars: they've developed the process during 25 hard-thinking, hard-working years. Where a job can't be done by any other method, because the quantities needed are too small, Keetons will do it cheerfully by deep hole drilling at a much lower cost than you'd expect. For keen prices and quick delivery Keetona Hollow Bored Bars have the rest licked hollow!

Write for our new illustrated brochure telling you all about Keetona Hollow Bored Bars to

KEETON SONS & CO. LTD.

KEETONA WORKS, GREENLAND ROAD, SHEFFIELD, 9. TEL: SHEFFIELD 42961/4.

A MEMBER OF THE FIRTH CLEVELAND GROUP

TRADE KEETONA MARK

CBC 4835

Index to Current Advertisers and their Advertising Agents

Abbey Panel and Sheet Metal Co. Ltd., The — *Agency—Willington Advertising Ltd.*
Acru Electric Tool Mfg. Co. Ltd. —
A.C.V. Sales Ltd. — *Agency—Crane Publicity Ltd.*
Aldridge Plastics Ltd. A71 *Agency—L. Graham Browne (London) Ltd.*
Archdale, James, & Co. Ltd. A38
Armstrong Patents Co. Ltd A54 *Agency—Ingham, Butterworth Ltd.*
Armstrong Siddeley (Brockworth) Ltd. — *Agency—Alfred Pemberton Ltd.*
Ashmore, Benson, Pease & Co. A13
Automotive Engineering Ltd. A68 *Agency—W. S. Crawford Ltd.*
Automotive Products Company Ltd. A35 *Agency—H. Raymond Morgan*
Avo Ltd. — *Agency—National Publicity Co. Ltd.*

B.R.C. Engineering Co. Ltd. A43 *Agency—Murray Watson Ltd.*
B.S.A. Tools Ltd. Cover 4
B.T.R. Industries Ltd. — *Agency—Dorland Advertising Ltd.*
Beakbane, Henry, (Fortox) Ltd. Cover 3
Berardi, Rino Officine A21
Bird, W. H., & Sons Ltd. — *Agency—Walter Pearce & Co. Ltd.*
Birfield Group A72 *Agency—Central News Ltd.*
Borg & Beck Co. Ltd. — *Agency—H. Raymond Morgan*
Borg-Warner Ltd. — *Agency—Stowe & Bowden Ltd.*
Brady, G., & Co. Ltd. — *Agency—Stowe & Bowden Ltd.*
Brammer, H., & Co. Ltd. A97 *Agency—Morison's Press (Adv.) Service Ltd.*
Brayshaw Furnaces & Tools Ltd. — *Agency—Ingham Butterworth Ltd.*
British Electric Resistance Co. Ltd., The A93 *Agency—Dorland Advertising Ltd.*
British Electrical Repairs Ltd. — *Agency—Donald Macdonald (Adv.) Ltd.*
British Electrical Development Assn., The — *Agency—Mather & Crowther Ltd.*
British Oxygen Gases Ltd. A76 *Agency—F. C. Pritchard Wood & Partners Ltd.*
British Rolling Mills Ltd. A39 *Agency—Maurice G. Parker Ltd.*
British Rototherm Co. Ltd., The A93 *Agency—Pitchford's Advertising Ltd.*
British Thomson-Houston Co. Ltd., The A16 *Agency—Technical & General Adv. Agency Ltd.*
British Timken Ltd. — *Agency—H. Raymond Morgan*
Broadbent & Co. (Rochdale) Ltd. — *Agency—Arthur Burns Publicity*
Brockhouse, J., & Co. Ltd. — *Agency—A. N. Holden & Co. Ltd.*
Brockmoor Foundry Co. Ltd., The — *Agency—Willington Advertising Ltd.*
Bronx Engineering Co. Ltd., The A36 *Agency—A. N. Holden & Co. Ltd.*
Brown, Boveri & Co. Ltd. —
Brown, David, Corporation (Sales) Ltd., The A86 *Agency—Dudley Turner & Vincent Ltd.*
Burtonwood Engineering Co. Ltd. — *Agency—Stowe & Bowden Ltd.*

Caldwell, T., & Son Cover 3
Carobronze Ltd. —
Carter Gears Ltd. A31
Cashmore, John, Ltd. A90 *Agency—Sandbrook, Metcalf & Co. Ltd.*
Cementation (Muffelite) Ltd. — *Agency—Napper Stinton & Woolley Ltd.*
Central Tool & Equipment Co. Ltd. — *Agency—Applied Designs (Advertising) Ltd.*
Chapman & Hall Ltd. —
Chatwin, Thomas, & Co. — *Agency—A. N. Holden & Co. Ltd.*
Churchill, Charles, & Co. Ltd. — *Agency—Broadway Adv. Service Ltd.*
Churchill Machine Tool Co. Ltd., The Cover 1 *Agency—Associated British Machine Tool Makers Ltd.*
Churchill-Sturm Ltd. — *Agency—Broadway Adv. Service Ltd.*
Clarkson Engineers Ltd. — *Agency—Ripley Preston & Co. Ltd.*
Clayton-Wright, Howard, Ltd. — *Agency—Ripley Preston & Co. Ltd.*
Coin Insulation Ltd. — *Agency—Havas Ltd.*
Colt Ventilation Ltd. A12 *Agency—Greenlys Ltd.*
Cooper & Co. (B'ham) Ltd. — *Agency—Nicholls Dorrity Advertising Ltd.*
Consolidated Pneumatic Tool Co. Ltd. A81 *Agency—Crane Publicity Ltd.*
Cork Manufacturing Co. Ltd. — *Agency—H. Raymond Morgan*
Cossor Instruments Ltd. A20 *Agency—Saward, Baker & Co. Ltd.*
Coulthard, Wm., & Company Ltd. A30
Crofts (Engineers) Ltd. —
Croda Organisation, The — *Agency—Storey Evans & Co. Ltd.*
Cronite Foundry Co. Ltd., The Cover 2
Crossley Brothers Ltd. — *Agency—Osborne-Peacock Co. Ltd.*
Crowthorn Engineering Co. Ltd. A4 *Agency—J. K. Clayton Advertising Ltd.*
Curnon Engineering Co. — *Agency—Portland Advertising Service Ltd.*

Delapena & Son Ltd. A55 *Agency—S. D. Toon & Heath Ltd.*
Deloro Stellite Ltd. A14
Diamond Screw & Cotter Co. Ltd., The A102 *Agency—A. N. Holden & Co. Ltd.*
Dubied, Edouard, & Cie, S.A. A78 & A98
Dunlop Rubber Co. Ltd. A73 *Agency—Charles F. Higham Ltd.*

Eagle Pencil Co. — *Agency—Saward Baker & Co. Ltd.*
Elcontrol Ltd. — *Agency—Fredk. E. Potter Ltd.*
Electric Construction Co. Ltd., The —
Electric Resistance Furnace Co. Ltd. — *Agency—Nigel Rainbow & Partners Ltd.*
Electrical Power Engineering Co. (B'ham) Ltd. A50 *Agency—Nicholls, Dorrity Advertising Ltd.*
Electro-Dynamic Construction Co. Ltd. A57 *Agency—J. Peers and Associates Ltd.*
Elgar Machine Tool Co. Ltd. — *Agency—Howard Panton Ltd.*
Elliott, E., Ltd. — *Agency—Sterling Advertising Ltd.*
Ellison, George, Ltd. — *Agency—Crossley & Co. Ltd.*
English Electric Co. Ltd., The — *Agency—Technical Adv. Service*
English Glass Co. Ltd., The A94 *Agency—Frank Gayton Advertising Ltd.*
English Steel Tool Corporation — *Agency—Technical & General Adv. Agency Ltd.*
ENV Engineering Co. Ltd — *Agency—Allardyce Palmer Ltd.*
Evertaut Ltd. — *Agency—Elliott Advertising Ltd.*

Fabbrica Nazionale Seghette da Metallo S.p.A. —
Factory Equipment Exhibitions Ltd. A77 *Agency—London Press Exchange Ltd.*
Faure-Herman Ets. —
Fibreglass Ltd. A65 *Agency—Cecil D. Notley Adv. Ltd.*
Firth Brown Tools Ltd. — *Agency—Stanley D. Dickson*
Firth Cleveland Steel Strip Ltd. — *Agency—C. R. Casson Ltd.*
Firth-Derihon Stampings Ltd., The A17 *Agency—Stanley D. Dickson*
Firth, Thos., & John Brown Ltd. — *Agency—Stanley D. Dickson*
Fischer Bearings Co. Ltd. A82 *Agency—H. Raymond Morgan*
Flame Hardeners Ltd. A95
Flexello Castors & Wheels Ltd. A92 *Agency—Dudley Turner & Vincent Ltd.*
Fodens Ltd. — *Agency—A. H. Knowles Ltd.*
Follsain-Wycliffe Foundries, Ltd. 131
Ford Motor Co. Ltd. A26 *Agency—Rumble Crowther & Nicholas Ltd.*
Fordsmith, H., Ltd. — *Agency—Arthur Burns Publicity*
Francis, Wm. C., Ltd. —
Fraser, Andrew, & Co. Ltd. — *Agency—J. Peers and Associates Ltd.*

Gas Council, The — *Agency—C. P. Wakefield Ltd.*
General Electric Co. Ltd., The A3
Gibbons Bros. Ltd. A50 *Agency—Elliott Advertising Ltd.*
Gloucester Foundry Ltd. A83 *Agency—Print for Industry Ltd.*
Goodyear Tyre & Rubber Co. (G.B.) Ltd., The A69 *Agency—Erwin Wasey Ruthrauff & Ryan Ltd.*
G.P.A. Tools & Gauges Ltd. —
Griffiths, A. E. (Smethwick) Ltd. —
Griffiths, Gilbart Lloyd & Co. Ltd. — *Agency—Nicholls Dorrity Advertising Ltd.*
Guest, Keen & Nettlefolds (Midlands) Ltd. — *Agency—Cecil D. Notley Adv. Ltd.*
G.W.B. Furnaces Ltd. A88 *Agency—Crane Publicity Ltd.*

Hackbridge & Hewittic Electric Co. Ltd. — *Agency—Industrial Publicity Service Ltd.*
Hallamshire Steel & File Co. Ltd., The A58 *Agency—Downtons Ltd.*
Hall, Harding Ltd. Cover 2
Hallmac Tools Ltd. A44 *Agency—Jack White & Associates*
Hancock & Co. (Engineers) Ltd. — *Agency—Tibbenham Publicity Ltd.*
Harcourt, David, Ltd. — *Agency—Allardyce Palmer Ltd.*
Harpurhey Precision Engineers Ltd., The — *Agency—Arthur Burns Publicity*
Harris, John, Tools Ltd. A45 *Agency—Sinclair Advertising Agency*
Harvey, G. A., & Co. (London) Ltd. A49 *Agency—G. P. Hughes Advertising*
Hathernware Ltd. — *Agency—Donald Macdonald (Adv.) Ltd.*
Heap, Joshua, & Co. Ltd. A36
Heath Spring & Notion Co. Ltd., The — *Agency—Tom C. Gough*
Heenan & Froude Ltd. — *Agency—Kenley Advertising Ltd.*
Hermetic Rubber Co. Ltd. A60
Hilger & Watts Ltd. A79 *Agency—Crane Publicity Ltd.*
Hoffmann Mfg. Co. Ltd., The —
Holden, Arthur, & Sons Ltd. — *Agency—S. D. Toon & Heath Ltd.*
Holroyd, John, & Co. Ltd. A27 *Agency—C. R. Casson Ltd.*
Horstmann Gear Co. Ltd., The — *Agency—Trowbridge Pritchard & Co. Ltd.*
Hughes, Geo. H., Ltd. A85 *Agency—Elliott Advertising Ltd.*
Hunt & Mitton Ltd. A88 *Agency—Tom C. Gough & Partner Ltd.*
Hygate, John, (Bath) Ltd. — *Agency—Trowbridge Pritchard & Co. Ltd.*
Hymatic Engineering Co. Ltd., The — *Agency—London Press Exchange Ltd.*

Ilford Ltd. — *Agency—Samson Clark & Co. Ltd.*
Imperial Chemical Industries Ltd. — *Agency—Clifford Martin Ltd.*
Impregnated Diamond Products Ltd. A41 *Agency—E. Allan Cooper & Co. Ltd.*

Index *(continued)*

Industrial Exhibitions Ltd. A77
Agency—Commercial Publicity (London) Ltd.
Industrial Fan & Heater Co. Ltd. —
Agency—Sinclair Advertising Agency
Insuloid Manufacturing Co. Ltd. A93
Agency—W. Hopwood & Co.
International Combustion Products Ltd. A47
Agency—Technical & General Adv. Agency Ltd.

Johnson Foster, H., Ltd. —

Kayser, Ellison & Co. Ltd. A59
Agency—Stowe & Bowden Ltd.
Keelavite Rotary Pumps and Motors Ltd. A19
Agency—Cogent Advertising Service Ltd.
Keeton, Sons & Co. Ltd. A99
Agency—C. R. Casson Ltd.
Kendall & Gent Ltd. —
Agency—Associated British Machine Too Makers Ltd.
Kirkham, J. & W., Ltd. A96

Lang Pneumatic Ltd. A61
Agency—J. Peers and Associates Ltd.
Lewis Spring Co. Ltd., The 126
Agency—Nicholls Dorrity Adv. Ltd.
Ley's Malleable Castings Co. Ltd. —
Agency—H. Raymond Morgan
Lincoln Electric Co. Ltd. A51
Agency—London Press Exchange Ltd.
Linread Ltd. A70
Agency—Beardmore Advertising Ltd.
Lloyd, F. H., & Co. Ltd. —
Agency—Print for Industry Ltd.
Lodge Plugs Ltd. A81
Agency—Elliott Advertising Ltd.

Madan, Chas. S., & Co. Ltd. —
Agency—Portland Advertising Ltd.
Magnetic Devices Ltd A15
Agency—Arks Publicity Ltd.
Magnetic Valve Co. Ltd., The —
Agency—Crane Publicity Ltd.
Measurement Ltd. A52
Agency—Robert Brandon & Partners Ltd.
Metalifacture Ltd. —
Agency—Rex Publicity Service Ltd.
Metropolitan-Vickers Electrical Co. Ltd. A33
Agency—Technical & General Advertising Agency Ltd.
Midland Industries Ltd. A91
Agency—A. A. Black Ltd.
Minganti, Giuseppe, & Co. A29
Mining & Chemical Products Ltd. —
Agency—John Mitchell & Partners Ltd.
Minnesota Mining & Mfg. Co. Ltd. —
Mirrlees, Bickerton & Day Ltd. A1
Agency—Rowlinson-Broughton
Monks & Crane Ltd. A62
Agency—Sandbrook, Metcalf & Co. Ltd.
Moon Bros. Ltd. —
Agency—Douglass & Co. Ltd.
Morgan Crucible Co. Ltd., The A18
Morris, Herbert, Ltd. A24
Morris, B. O., Ltd. —
Agency—Cogent Advertising Service Ltd.
Mountford, Frederick, (B'ham) Ltd. A54
Agency—S. D. Toon & Heath Ltd.
Myford Engineering Co. Ltd. A52

Napier, D., & Son Limited A25
Agency—C. R. Casson Ltd.
Neill, James, & Co. (Sheffield) Ltd. A80
Agency—J. K. Clayton Adv. Agency Ltd.
Newage (Manchester) Ltd. A2
Agency—Howard Panton Ltd.
Newall, A. P., & Co. Ltd. A40
Agency—Osborne-Peacock Co. Ltd.
Newall Group Sales Ltd. A6
Agency—J. Peers and Associates Ltd.
Newton, Chambers & Co. Ltd. —
Agency—Stanley D. Dickson
Nitralloy Ltd. A102
Agency—Stanley D. Dickson
North British Rubber Co. Ltd., The —
Agency—The Robert Freeman Co. Ltd.

Osborn, Samuel, & Co. Ltd. A7

Palmer, G. A. Stanley, Ltd. —
Agency—Divers Advertising
Parmiter, Hope & Sugden Ltd. —
Agency—Donald Macdonald (Advertising) Ltd.
Payne & Griffiths Ltd. —
Agency—Sandbrook, Metcalf & Co. Ltd.
Pell, Oliver, Control Ltd. A53
Agency—S. C. Peacock Ltd.
Perry Barr Metal Co. Ltd. —
Agency—Tom C. Gough & Partners Ltd.
Pilkington Bros. Ltd. —
Agency—F. C. Pritchard Wood & Ptnrs. Ltd.
Pioneer Oilsealing & Moulding Co. Ltd. —
Agency—Hyde & Partners Ltd.
Pitman, Sir Isaac, & Sons Ltd. A63
Positive Lock Washer Co. Ltd. A94
Agency—Peter A. Menzies Advertising
Precision Screw & Mfg. Co. Ltd., The —
Agency—Seal Advertising Service
P.R. Motors Ltd. A32
Agency—A. A. Black Ltd.

Radio Heaters Ltd. —
Agency—J. Peers & Associates Ltd.
Ransome & Marles Bearing Co. Ltd. A37
Agency—Ruddocks Advertising Agency
Ransomes Sims & Jefferies Ltd. —
Agency—A.T.A. Advertising Ltd.
Rapid Magnetic Machines Ltd. —
Agency—Edward Hilton Advertising Ltd.
Ratcliffe, F. S. (Rochdale) Ltd. A97
Agency—Osborne-Peacock Co. Ltd.
Rawsthorne's (Bolton) Ltd. —
Revolvo Ltd. —
Agency—Ripley Preston & Co. Ltd.
Reynolds Tube Co. Ltd. A95
Agency—Ripley, Preston & Co. Ltd.
Richards, Charles, & Sons Ltd. —
Agency—Longleys & Hoffmann Ltd.
Riley, Robert, Ltd. —
Agency—Commercial Advertising Service Ltd.
Rivlink Belts Ltd. —
Roberts, J. W., Ltd. A74
Agency—Armstrong-Warden Ltd.
Robinson, L., & Co. (Gillingham) Ltd. A94
Agency—Ripley Preston & Co. Ltd.
Rocol Ltd. —
Agency—Nevin D. Hirst (Advertising) Ltd.
Rotherham & Sons Ltd. —
Agency—George Murray Advertising Ltd.

Salter, Geo., & Co. Ltd. A28
Agency—Severn Publicity Ltd.
Sanderson Bros. & Newbould Ltd. A87
Sandiacre Screw Co. Ltd., The —
Agency—Bemrose Advertising Ltd.
Sandwell Casting Co., The —
Agency—Edward Hilton Advertising Ltd.
Saturn Industrial Gases Ltd. A42
Agency—Crossley & Co. Ltd.
Savery, Thomas, Pumps Ltd. A56
Agency—Nicholls Dorrity Adv. Ltd.
Self-changing Gears Ltd. —
Selson Machine Tool Co. Ltd., The A58
Agency—S. C. Peacock Ltd.
Sentinel (Shrewsbury) Ltd. A10
Agency—J. Peers & Associates Ltd.
Serck Radiators Ltd. —
Agency—Longleys & Hoffmann Ltd.
Sheffield Twist Drill & Steel Co. Ltd., The A23
Sherborne Rubber Co. Ltd., The —
Agency—Sinclair Advertising Agency
Sintered Metal Components Ltd. —
Agency—Jack White and Associates
Smith, W. H., & Son Ltd. A79
Spa Plastics Ltd. A48
Spear & Jackson Ltd. A99
Agency—Oelrichs Advertising Ltd.
Spencer (Melksham) Ltd. A102
Agency—Trowbridge Pritchard & Co. Ltd.
Spencer Wire Co. Ltd. —
Agency—Divers Advertising
Standard Telephones & Cables Ltd. —
Agency—Brockie Haslam & Co.
Star Foundry Ltd., The A60
Agency—Tom C. Gough & Partners Ltd.
Steel, J. M., & Co. Ltd. A91
Agency—Reynell & Son Ltd.
Stone-Chance Ltd. A75
Agency—Notley Advertising Ltd.
Sykes, W. E., Ltd. —
Agency—Warren Seymour & Co. Ltd.

Tangyes Ltd. A67
Taylor, Taylor & Hobson Ltd. A22
Agency—Pitchfords Advertising Ltd.
Teddington Industrial Equipment Ltd. —
Agency—Crane's Publicity Ltd.
Terry, Herbert, & Sons Ltd. A46
Agency—John Haddon & Co. Ltd.
Thompson, John, Water Tube Boilers Ltd. A64
Agency—Rowlinson-Broughton
Torrington Co. Ltd., The —
Agency—Osborne-Peacock Co. Ltd.
Tufnol Ltd. A11
Agency—Crossley & Co. Ltd.
Turner Brothers Asbestos Co. Ltd. A96
Agency—Donald Macdonald (Advertising) Ltd.
Turner, Ernest, & Co. (Salford) Ltd. —
Tyre Products Ltd. 130
Agency—Rylee (Advertising) Ltd.

Uni-Tubes Ltd. —
Agency—Frederick Aldridge Ltd.
Universal Conveyor Co. Ltd. A96
Agency—John Halifax Ltd.

Vaughan Crane Co. Ltd., The —
Vaughan, Edgar, & Co. Ltd. A5
Agency—Oldfield & Sharp
Vickers-Armstrongs (Engineers) Ltd. —
Agency—Technical & General Adv. Agency Ltd.
Victor Products (Wallsend) Ltd. —
Agency—Doig Advertising Ltd.
Visco Engineering Co. Ltd. —
Agency—Ernest Ingram Hill Ltd.
Vokes Ltd. —
Agency—Crane Publicity Ltd.
Vulcascot (Gt. Britain) Ltd. 128

Wakefield-Dick Industrial Oils Ltd. —
Agency—Dorland Advertising Ltd.
Walker, Crosweller & Co. Ltd. A8 & A9
Agency—Beardmore Advertising Ltd.
Walker, M. W., & Staff Ltd. —
Agency—Alfred Bates & Son Ltd.
Walpamur Co. Ltd., The A98
Agency—Osborne-Peacock Co. Ltd.
Ward (Metal Details) Ltd. —
Agency—Beardmore Advertising Ltd.
Ward, Thos. W., Ltd. A84
Agency—Oelrichs Advertising Ltd.
Weston, Chas., & Co. Ltd. A34
Agency—Cross-Courtenay Ltd.
Westool Ltd. —
Agency—Tibbenham Publicity Ltd.
Whitehouse, Wm., & Co. Ltd. A91
Agency—Severn Publicity Ltd.
Whittaker, Hall & Co. (1929) Ltd. —
Agency—Ingham Butterworth Ltd.
Whittle, T., & Sons Ltd. A94
Agency—Baird & Dawson Ltd.
Whyte & Collins Ltd. —
Agency—Sandbrook, Metcalf & Co. Ltd.
Wilcox, Edward, & Co. Ltd. —
Agency—Donald Macdonald (Advertising) Ltd.
Wicksteed, Charles & Co. (1920) Ltd. —
Agency—Nicholls, Dorrity Advertising Ltd.
Wolverhampton Die Casting Co. Ltd., The A66
Agency—Sterling Advertising Ltd.
Wright, Bindley & Gell Ltd. —
Agency—L. J. Fowler & Co. Ltd.
Wynstruments Ltd. A95
Agency—Kenley Advertising Ltd.

Zinc Alloy Rust-Proofing Co. Ltd. A92
Zwicky Ltd. —
Agency—Richards & Thompson

for the quick turn-round of ships in port

This illustration shows two of the four Travelling Pneumatic Grain Elevators recently installed by Spencers of Melksham at the King George Dock, Hull, for the British Transport Commission.

These elevators are part of the modernization scheme lately carried out at the Port of Hull. Each is capable of a peak discharging rate of 150 tons per hour. The turn-round time of ships in port is greatly reduced when using such elevators.

SPENCER

PNEUMATIC ELEVATORS

SPENCER (MELKSHAM) LIMITED · MELKSHAM · WILTSHIRE

Branch Offices: INGERSOLL HOUSE, KINGSWAY, LONDON, W.C.2 Tel. Covent Garden 1800
34 CASTLE STREET, LIVERPOOL, 2. Tel. CENtral 3738

NITRIDED *Nitralloy* STEELS

The Nitriding Process for Case-hardening Special Steels by Nitrogen Offers

- **Surface hardness up to 1100 D.P.H.**
- **Retention of full hardness after heating to 500°C.**
- **Maximum resistance to frictional wear and fatigue.**
- **Improved resistance to corrosion by water and steam.**

Particulars from:-

NITRALLOY LIMITED ATLAS WORKS SHEFFIELD, 4.

Telephone: Sheffield 26646. Telegrams: "Nitralloy, Sheffield"

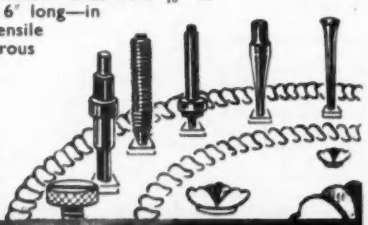
A102

1907 A 51-year reputation 1958 *for*

REPETITION WORK

● In 1958 we are still producing, among countless other Precision Repetition Products—in almost all metals—the standard Taper Pins which were our speciality over 50 years ago. Latest addition to our service is a Cold Heading Section producing formed parts of a special nature—sizes from $\frac{1}{16}$" to $\frac{1}{2}$" dia. and up to 6" long—in Mild Steel, High Tensile Steel and Non-ferrous Metals.

*Fully approved by M.O.S. 6/49 and Air Registration Board.

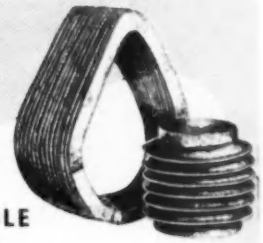


The DIAMOND SCREW & COTTER CO. LTD

CHERRYWOOD RD BORDESLEY GREEN BIRMINGHAM 9

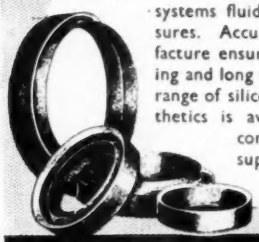
Fortox

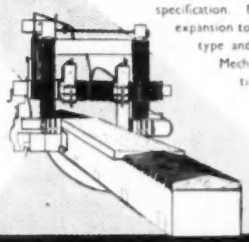
INDUSTRIAL LEATHERS MANUFACTURED TO SPECIFICATION



HYDRAULIC LEATHERS AND PACKINGS

are manufactured for all types of systems fluids and pressures. Accuracy of manufacture ensures positive sealing and long trouble free life. A range of silicone leathers and synthetics is available for extreme conditions. Single items supplied promptly.





FORTOX FLEXIBLE BELLOWS *protect machinery and exclude dirt.*

All shapes and sizes manufactured exactly to your specification. New type of construction gives an expansion to contraction ratio of 10:1. Prototype and development work a speciality. Mechanical leathers of all descriptions. Write today for enquiry forms and full details of our work.

HENRY BEAKBANE (FORTOX) LIMITED

HEAD OFFICE AND TANNERY
THE TANNERY · STOURPORT ON SEVERN · WORCS.
TELEPHONE · STOURPORT 2017

68 - 70 LANT STREET BOROUGH S. E. 1.
LONDON WORKS
TELEPHONE · HOP 0488

CALDWELLS OF BOLTON FOR STAINLESS STEEL

Chemical Plant,

Mixing Vessels,

Storage Vessels,

Tanks, Ducting,

Piping, Flanges.

SPECIALISTS IN STAINLESS STEEL AND MILD STEEL FABRICATION.

CONSTRUCTIONAL STEELWORK.

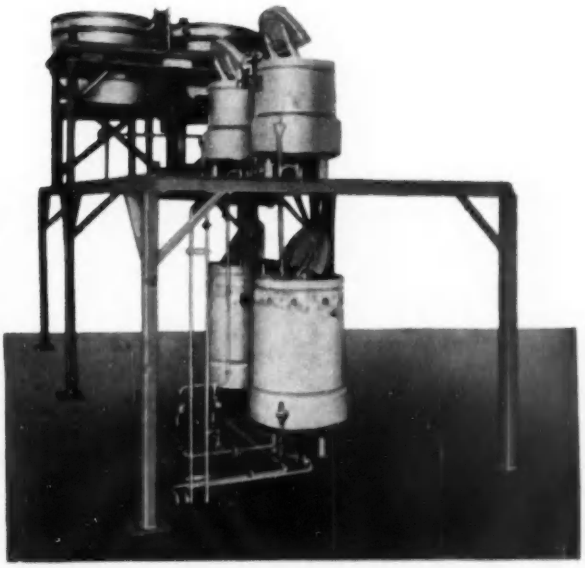
CAPSTAN AND REPETITION WORK.

SEND YOUR ENQUIRIES TO:

T. CALDWELL & SON

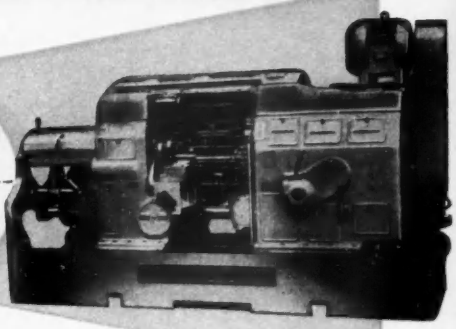
ST. JOHN STREET, BOLTON

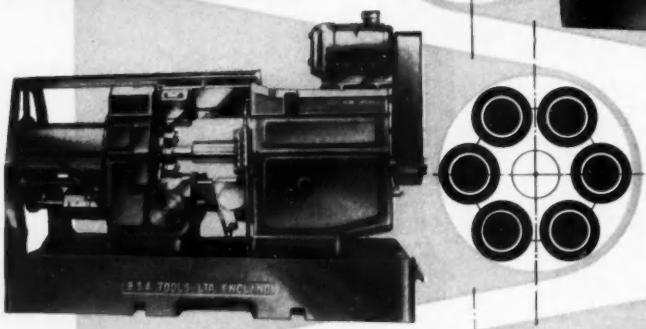
Est. 1877 Phone BOLTON 3672 (2 lines)



B·S·A ACME-GRIDLEY

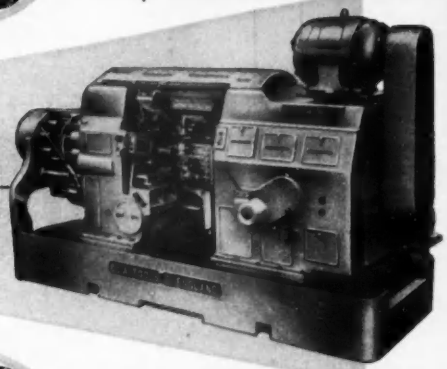
BAR
2 1/4", 3 1/2"
FOUR SPINDLE

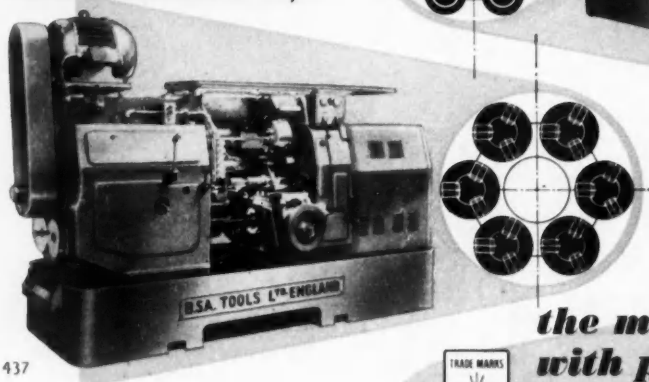




BAR
7/16", 1", 1 1/4", 1 5/8", 2 5/8"
SIX SPINDLE

BAR
1 5/8"
EIGHT SPINDLE



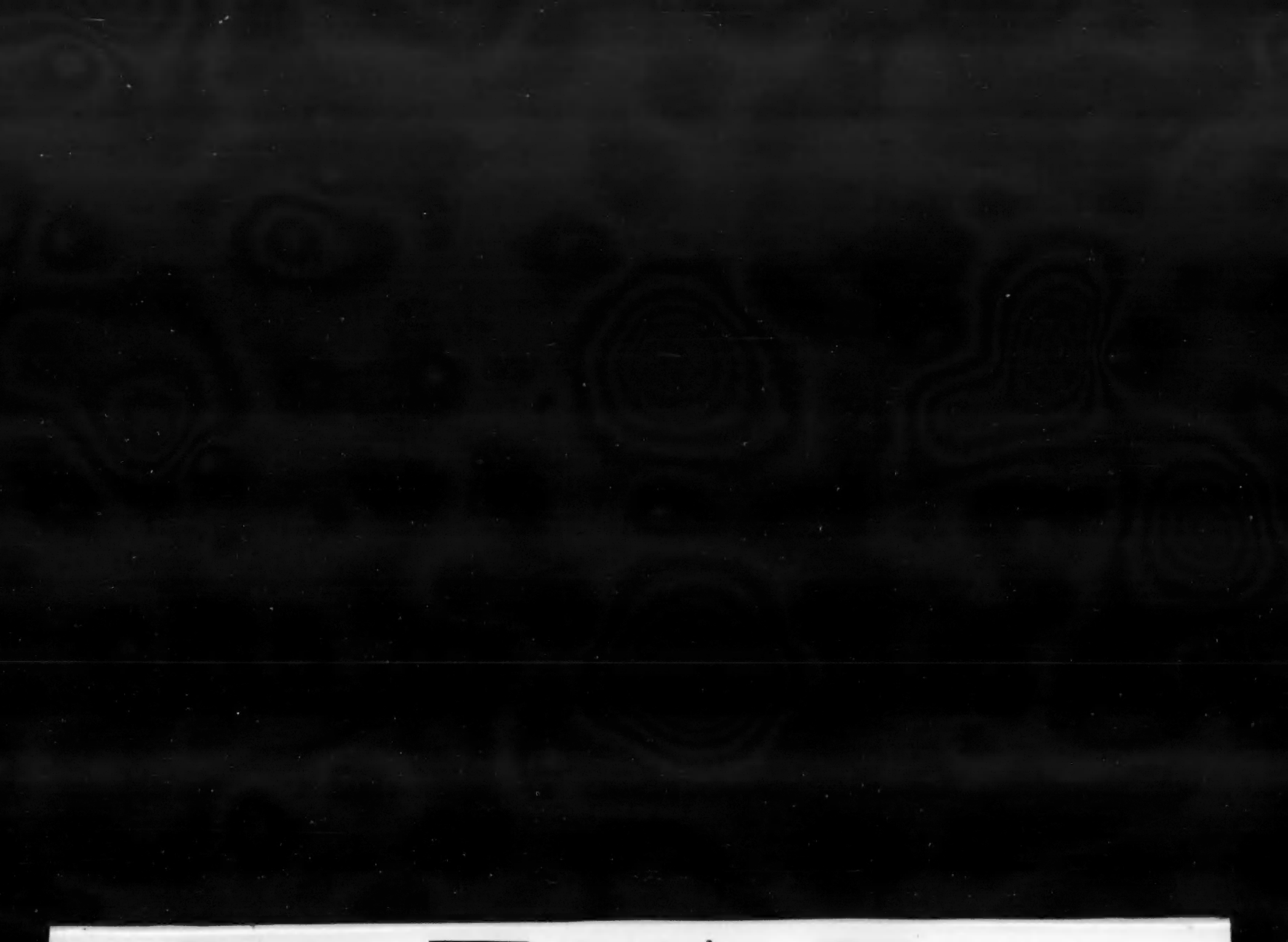


CHUCKING
6"
SIX SPINDLE

437

the multi-spindle autos with positive direct-action quick-change cam control

TRADE MARKS
B·S·A TOOLS GROUP

MAKERS:
B.S.A. TOOLS LTD · BIRMINGHAM · 33
ENGLAND

SOLE AGENTS GT BRITAIN BURTON GRIFFITHS & CO LTD KITTS GREEN BIRMINGHAM STECHFORD 3071